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Veterinary Anesthesia Drug Quick Reference

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1st ed.

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NOTICE

Domestic animal practice is an ever-changing field. Standard safety precautions must be followed, but as new research and clinical experience grow, changes in treatment and drug therapy become necessary or appropriate. The authors and editors of this work have carefully checked the generic and trade drug names and verified drug dosages to assure that dosage information is precise and in accord with standards accepted at the time of publication. Readers are advised, however, to check the product information currently provided by the manufacturer of each drug to be administered to be certain that changes have not been made in the recommended dose or in the contraindications for administration. This is of particular importance in regard to new or infrequently used drugs. Recommended dosages for animals are sometimes based on adjustments in the dosage that would be suitable for humans. Some of the drugs mentioned here have been given experimentally by the authors. Others have been used in dosages greater than those recommended by the manufacturer. In these kinds of cases, the authors have reported on their own

considerable experience. It is the responsibility of those administering a drug, relying on their professional skill and experience, to determine the dosages, the best treatment for the patient, and whether the benefits of giving a drug justify the attendant risk. The editors cannot be responsible for misuse or misapplication of the material in this work.

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1 Chapter 1 Individual Drugs

1.1 ACEPROMAZINE

PromAce	*Fort Dodge Laboratories*
Aceproject	*Vetus Animal Health*

1.1.1 Approved for

- Dogs, cats, horses not intended for food

1.1.2 Features

- Phenothiazine tranquilizer or sedative
- Alpha antagonist
- Antiemetic
- Antihistaminic
- Antidysrhythmic

1.1.3 Uses

- Sedation and tranquilization
  - Before general anesthesia
  - Before travel or transport
  - In patients with “thunderstorm anxiety”
- Addition to opiate analgesic to produce neuroleptanalgesia

1.1.4 Precautions

- No analgesia (not to be used for painful procedures unless administered with analgesic)
- Use with caution in hypotensive or hypovolemic patients
- Thought to decrease seizure threshold; avoid excessive doses in seizure-prone patients
- Boxers, large-breed dogs, and geriatric patients may show increased sensitivity (avoid or use low dose)
- Splenic engorgement via red blood cell sequestration (hematocrit may drop up to 50%)

- Inhibits temperature regulation

- Risk of priapism in male horses. Priapism has been treated successfully in two horses with IV benztropine at 8 mg/horse. Use as soon as possible after priapism occurs.*

* From Wilson DV, Nickels FA, Williams MA: Pharmacologic treatment of priapism in two horses, *J Am Vet Med Assoc* 199:1183, 1991.

1.1.5 Doses

Doses of Acepromazine by Species

Species	IV (mg/kg)	IM, SC (mg/kg)	Oral (mg/kg)
Horses	0.02–0.04*	0.04–0.08	0.13–0.26
Cattle	0.025–0.05	0.025–0.1	0.1–0.2
Sheep	0.025–0.05	0.05–0.1	NR
Goats	0.025–0.05	0.05–0.1	NR
Pigs	0.05–0.1	0.1–0.2	1–4
Dogs	0.025–0.05	0.025–0.1†	1–3
Cats	0.025–0.05	0.025–0.1‡	0.25–0.5
Rabbits	0.025–0.05	0.025–0.1	NR
Ferrets	0.025–0.05	0.025–0.1	NR

NR, Not recommended.

* Maximum 20 mg.

† Maximum 3 mg.

‡ Maximum 1 mg.

1.2 ATIPAMEZOLE

Antisedan*Pfizer, Inc.*

1.2.1 Approved for

- Dogs

1.2.2 Features

- Alpha$_2$ adrenergic receptor antagonist
- Reverses all effects of alpha$_2$ agents, including analgesia
- Increases heart rate and respiratory rate and reduces sedation
- Occasionally causes vomiting, diarrhea, and salivation

1.2.3 Uses

- Reversal of medetomidine sedation

- Can also be used to reverse other alpha$_2$ agents (e.g., xylazine)
- Drug is formulated such that the volume of atipamezole required for intramuscular (IM) injection equals the volume of medetomidine administered intravenously (IV) or IM
- If ineffective after 10 to 15 minutes, use another IM dose at half the volume of medetomidine
- Approximately 45 minutes after medetomidine is given, use of atipamezole IV at half the volume of medetomidine is acceptable

1.2.4 Precautions

- Preferable to use IM route
- IV injection may cause excitement or aggression; inject slowly and in increments
- Because the analgesia of the alpha$_2$ drug is reversed, use other agents for continued analgesia if necessary

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1.2.5 Doses

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Doses of Atipamezole by Species

Species	IM (mg/kg)	IV (mg/kg)
Horses*	—	0.05–0.1
Dogs	Use volume equal to volume of medetomidine used	Use volume equal to half of volume of medetomidine used, preferably after approximately 45 minutes
Rabbits	0.25–0.5	0.001 IV, SC, IP†
Ferrets	0.1	1 IV, SC, IP‡

* Used in horses for detomidine overdose.

† Concentration of drug is 5 mg/ml. Dose rate of 0.001 mg/kg = 0.0002 mg/kg. A 5-kg rabbit would require 0.001 ml.

‡ Dose rate of 1 mg/kg = 0.2 ml/kg.

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1.3 ATRACURIUM

Tracrium *GlaxoSmithKline*

1.3.1 Approved for

- No veterinary species

1.3.2 Features

- Nondepolarizing neuromuscular blocker

- Competes with acetylcholine (ACh) molecules released at the neuromuscular junction to bind with the ACh receptors on the postsynaptic membrane of the motor endplate without triggering a response
- Short duration of effect (25 to 35 minutes)
- Metabolized via ester hydrolysis and spontaneous Hofmann elimination (degradation at normal body temperature and pH)
- Requires refrigeration (drug deteriorates at room temperature)
- Safe in patients with hepatic or renal dysfunction

1.3.3 Uses

- Adjunct to general anesthesia; patient *must* be anesthetized before atracurium is administered
- Muscle relaxation for surgical procedures (e.g., ophthalmic, orthopedic)

1.3.4 Precautions

- No analgesia (not to be used for painful procedures unless administered with analgesic)
- Ventilation necessary
- May cause histamine release
- Reversal agent (anticholinesterase) required for reversal
- Prolonged effect in hypothermic and acidotic patients
- Aminoglycoside antibiotics (e.g., gentamicin) and volatile agents may increase duration of neuromuscular blockade
- Contraindicated in patients with myasthenia gravis or other neuromuscular disorders associated with weakness

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1.3.5 Doses

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Doses of Atracurium by Species

Species	IV—Initial Dose (mg/kg)	IV—Repeat Dose (mg/kg)
Horses	0.2	0.1
Cattle	0.2	0.1
Sheep	0.2	0.1
Goats	0.2	0.1
Pigs	0.2	0.1
Dogs	0.25	0.1
Cats	0.22	0.1
Rabbits	0.2	0.1
Ferrets	0.2	0.1

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1.4 ATROPINE

Atropine	*Butler Company*
Atroject	*Vetus Animal Health*

1.4.1 Approved for

- Dogs, cats, horses, cattle, sheep, swine

1.4.2 Features

- Naturally occurring alkaloid of *Atropa belladonna*
- Competitive antagonist of muscarinic cholinergic receptors

1.4.3 Uses

- Blocks the bradycardia associated with some drugs used in anesthesia
- Prevention of bradycardia resulting from excessive vagal stimulation or from anticholinesterase administration during neuromuscular blockade reversal
- Decreases bronchial and salivary secretions
- Bronchodilator
- Antidote for organophosphate toxicosis

1.4.4 Precautions

- Crosses the blood-brain barrier (pupillary dilation)
- Central nervous system (CNS) stimulation at high doses
- Sinus tachycardia may result; use with caution in patients with cardiac disease
- Contraindicated in patients with narrow-angle glaucoma and paralytic ileus
- Approximately one third of all domesticated rabbits have a naturally occurring atropinesterase enzyme that causes them to metabolize atropine more quickly than normal rabbits; may need to repeat dose frequently or use glycopyrrolate instead
- Can result in gastrointestinal stasis; avoid routine use in horse; use with caution in ruminants

1.4.5 Doses

Doses of Atropine by Species

Species	IV (mg/kg)	IM, SC (mg/kg)
Horses	0.01–0.02	0.005–0.01
Cattle	0.02–0.04	0.005–0.01
Sheep	0.02–0.04	0.005–0.01
Goats	0.02–0.04	0.05–0.01
Pigs	0.06–0.08	0.04–0.06
Dogs	0.01–0.02	0.02–0.04
Cats	0.01–0.02	0.02–0.04
Rabbits	0.04–1	0.04–2
Ferrets	0.01–0.02	0.02–0.04

1.5 BUPIVACAINE

Marcaine *Abbott Laboratories*

1.5.1 Approved for

- No veterinary species

1.5.2 Features

- Amide local anesthetic
- Produces reversible depression of nerve conduction by blocking sodium channels
- Prevents rapid influx of sodium ions into nerve axon and production of action potential, resulting in local muscle paralysis and analgesia
- Slow onset (3 to 6 minutes)
- Long duration of action (4 to 6 hours)
- Metabolized by liver and excreted by the kidneys

1.5.3 Uses

- Regional analgesia and muscle relaxation
- Nerve blockade
- Analgesia for standing surgery (e.g., castration, dehorning, enucleation)

1.5.4 Precautions

- Never use IV because of cardiotoxicity
- Toxic dose for most species is 2 to 3 mg/kg
- Cats are most sensitive to toxic effects of local anesthetics
- Toxic effects of overdose produce either CNS effects (seizures) or cardiovascular effects (arrhythmias or cardiovascular collapse)
- Treatment after overdose is supportive

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1.5.5 Doses

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For single nerve block, use 0.5 to 2 ml per nerve site.

Doses of Bupivacaine by Species

Species	Infiltration (mg/kg)	Epidural (mg/kg)	Intrapleural (mg/kg)
Horses	1	0.05	NR
Cattle	1	0.05	NR
Sheep	0.05	0.05	1
Goats	0.05	0.05	1
Pigs	1	0.05	1.5
Dogs	2	1	1.5
Cats	2	0.05	1.5
Rabbits	2	NR	NR
Ferrets	1	NR	NR

NR, Not recommended.

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1.6 BUPRENORPHINE

Buprenorphine*Abbott Laboratories*

1.6.1 Approved for

- No veterinary species

1.6.2 Features

- U.S. Drug Enforcement Administration (DEA) Schedule III controlled substance
- Partial agonist at mu opiate receptor
- Long onset (30 to 45 minutes)
- Long duration (4 to 6 hours)

- Minimal respiratory depression compared with pure opiate agonists
- Minimal cardiovascular depression compared with pure opiate agonists
- Injectable form can be used sublingually in cats without salivation or resentment, with pharmacokinetics similar to those seen with IV or IM administration; dose is 0.01 mg/kg*

* From Robertson SA, Taylor PM, Bloomfield M, Sear JW: Systemic uptake of buprenorphine by cats after oral mucosal administration, *Vet Rec* 152(22):675, 2003.

1.6.3 Uses

- Premedication before surgery
- Mild-to-moderate pain relief
- Addition to sedative or tranquilizer to produce neuroleptanalgesia

1.6.4 Precautions

- Difficult to reverse because of high affinity of drug for mu opiate receptor

1.6.5 Doses

Doses of Buprenorphine by Species

Species	IV (mg/kg)	IM, SC (mg/kg)
Horses	NA	NA
Cattle	0.005–0.01	0.005–0.01
Sheep	0.005–0.01	0.005–0.01
Goats	0.005–0.01	0.005–0.01
Pigs	0.01–0.1	0.01–0.1
Dogs	0.01–0.02	0.01–0.02
Cats	0.01–0.02	0.01–0.02
Rabbits	0.05–0.1	0.05–0.1
Ferrets	0.01–0.02	0.01–0.02

NA, Not appropriate.

1.7 BUTORPHANOL

Torbugesic	*Fort Dodge Laboratories*
Torbutrol	*Abbott Laboratories*

1.7.1 Approved for

- Dogs (Torbutrol)
- Cats (Torbugesic SA)

- Horses not intended for food (Torbugesic, Dolorex)

1.7.2 Features

- DEA Schedule IV controlled substance
- Agonist-antagonist with agonist activity primarily at kappa and sigma opiate receptors
- Antagonizes pure agonists such as morphine, oxymorphone, and fentanyl
- Significant antitussive activity in dogs
- No histamine release in dogs when given IV
- Fairly rapid onset (3 minutes IV; 20 minutes IM)
- Short-to-moderate duration (2 to 3 hours in dogs, 4 hours in horses)
- Minimal respiratory depression compared with pure opiate agonists
- Minimal cardiovascular depression compared with pure opiate agonists

1.7.3 Uses

- Premedication before surgery
- Mild-to-moderate pain relief
- Addition to sedative or tranquilizer to produce light level of neuroleptanalgesia
- Partial reversal of effects of pure agonists (e.g., in animals with slow recovery from anesthesia)
- Effective and well tolerated when administered orally in liquid form to cats

1.7.4 Precautions

- Caution must be exercised in patients with head trauma or conditions associated with increased cerebrospinal fluid (CSF) pressure

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- Respiratory and cardiovascular functions and body temperature must be monitored
- Some excitement may occur in horses (head tossing, auditory sensitivity)
- Decrease in gut motility is possible, especially at high doses
- Do not use for very painful conditions; if additional analgesia is required, other opioids will not be effective for several hours after butorphanol has been administered because of its antagonistic activity

1.7.5 Doses

Doses of Butorphanol by Species

Species	IV (mg/kg)	IM, SC (mg/kg)
Horses*	0.02–0.04	0.02–0.04
Cattle	0.01–0.04	0.01–0.04
Sheep	0.05†	0.05–0.5
Goats	NRP	0.05–0.5
Pigs	0.1–0.5	0.1–0.5
Dogs	0.1–0.4	0.1–0.4
Cats	0.1–0.8	0.1–0.8
Rabbits	0.1–0.5	0.1–0.5
Ferrets	0.1–0.5	0.1–0.5

NRP, Not reported.

* Usually used with xylazine or acepromazine for premedication.

† Excitement may occur at twice this dose or above.

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1.8 DETOMIDINE

Dormosedan*Pfizer, Inc.*

1.8.1 Approved for

- Mature horses and yearlings

1.8.2 Features

- Alpha$_2$ agonist
- Sedative and analgesic
- Similar to xylazine but with longer duration
- Decreases MAC and the requirement for other anesthetic agents (MAC is the minimum alveolar concentration of an anesthetic agent that prevents response to a noxious stimulus in 50% of patients; MAC is used for comparison of agents)
- Initial and transient vasoconstriction and hypertension (peripheral effect), then vasodilation and hypotension (central effect)
- Decreased heart rate and cardiac output
- Second-degree atrioventricular (AV) block commonly seen
- Increased blood glucose probably occurs, as with xylazine
- Piloerection, sweating, salivation, tremors, or ataxia may occur

- Reversed with yohimbine or atipamezole

1.8.3 Uses

- Sedation and analgesia for standing procedures
- Sedation before general anesthesia

1.8.4 Precautions

- Do not use in horses with preexisting sinoatrial (SA) or AV block
- Do not use in horses with chronic renal failure
- Do not use in horses with respiratory disease
- Use cautiously for treatment of colic pain, because long duration may mask progression of disease
- Use cautiously in horses with endotoxic shock

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- Use cautiously in stressed horses

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- Horses may respond suddenly to external stimuli even though apparently sedated

1.8.5 Doses

Doses of Detomidine by Species

Species	IV (mg/kg)	IM (mg/kg)
Horses	0.02–0.04	0.02–0.04
Cattle*	0.03–0.06	0.03–0.06

* Not approved for use in this species.

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1.9 DIAZEPAM

Diazepam *Baxter Healthcare Corporation*
Abbott Laboratories

1.9.1 Approved for

- No veterinary species

1.9.2 Features

- DEA Schedule IV controlled substance
- Benzodiazepine

- Acts at gamma-aminobutyric acid (GABA) receptor
- Anxiolytic
- Muscle relaxant
- Hypnotic
- Anticonvulsant

1.9.3 Uses

- Sedation and tranquilization
- Premedication—add to opiate analgesic to produce neuroleptanalgesia
- Treatment of muscle fasciculation induced by propofol or other anesthetics
- Treatment of seizures

1.9.4 Precautions

- No analgesia (not to be used for painful procedures unless administered with analgesic)
- Not well absorbed after IM administration (midazolam recommended)
- May cause excitement when administered alone (especially in cats and horses)
- Administer slowly IV to prevent hypotension (propylene glycol vehicle)
- Care required in patients with hepatic or renal disease or respiratory depression
- Care required in debilitated patients or those in shock

1.9.5 Doses

Doses of Diazepam by Species

Species	IV (mg/kg)	IM, SC (mg/kg)
Horses*	0.01–0.03	NA
Cattle	0.2–0.4	0.55–1
Sheep	0.2–0.4	0.2–1
Goats	0.2–0.4	0.2–1
Pigs	0.4–0.8	0.5–1.5
Dogs	0.1–0.2	0.1–0.5
Cats†	0.1–0.2	0.1–0.4
Rabbits	0.4–0.8	0.5–2
Ferrets	0.4–0.8	0.5–2

NA, Not appropriate.

* Not to be used alone; best used after premedication and as part of induction technique (e.g., with ketamine).

† Excitement may occur when used alone, especially IV; best used with other agents.

1.10 DOBUTAMINE

Dobutamine *Abbott Laboratories*
Baxter Healthcare Corporation

1.10.1 Approved for

- No veterinary species

1.10.2 Features

- Primarily a $beta_1$ agonist
- Mild $beta_2$ and $beta_1$ activity
- Increases stroke volume, myocardial contractility, and cardiac output
- Causes minimal change in heart rate or systemic vascular resistance
- Causes mild increase in blood pressure

1.10.3 Uses

- Treatment of hypotension during anesthesia

1.10.4 Precautions

- Preferable to use an infusion pump for administration in small animals
- Monitor electrocardiogram (ECG) and blood pressure carefully during use
- Use care in patients with atrial fibrillation
- May cause hypotension in hypovolemic patients
- Incompatible with sodium bicarbonate and furosemide
- Tachycardia, arrhythmias, and hypertension may result at high doses (>20 µg/kg/min)

1.10.5 Doses

1.10.5.1 For Horses

Add 4 ml dobutamine (12.5 mg/ml) to either 500 ml or 1 L of 0.9% saline or other IV solution (not bicarbonate) and drip slowly until effective.

1.10.5.2 For Smaller Animals

1.10.5.2.1 If using an infusion pump

For dobutamine at 12.5 mg/ml:

- Add 0.86 ml to 60 ml of 0.9% saline or other IV solution (not bicarbonate)
- Start at the lowest dose and adjust as necessary
- Effects are seen within approximately 2 to 5 minutes

Infusion rates for dobutamine based on this dilution

3 µg/kg/min	=	1 ml/kg/hr
6 µg/kg/min	=	2 ml/kg/hr
9 µg/kg/min	=	3 ml/kg/hr
12 µg/kg/min	=	4 ml/kg/hr

1.10.5.3 How the Dilution Was Calculated

For convenience, use pump settings of ml/kg/hr instead of µg/kg/min. Dilute the drug so that the lowest dose rate (3 µg/kg/min) = 1 ml/kg/hr. Dobutamine is supplied at 12.5 mg/ml. The lowest dose of 3 µg/kg/min = (3 × 60) µg/kg/hr = 180 µg/kg/hr. Make this dose equal to 1 ml/kg/hr. Therefore drug must be diluted so that 1 ml contains 180 µg (= 0.18 mg).

$$12.5\ \text{mg/ml} \div 0.18\ \text{mg/ml} = 69.4$$

Therefore the provided drug must be diluted by 69.4

To end up with a 60-ml volume in the infusion syringe, apply the following.

$$60\ \text{ml} \div 69.4 = 0.86\ \text{ml}$$

Therefore add 0.86 ml of dobutamine to 60 ml of saline.

1.10.5.4 Alternative Method of Preparation

- Draw up *x* mg of dobutamine, where $x = 6 \times$ weight in kilograms
- Add enough 5% dextrose in water (D5W) or 0.9% saline (not bicarbonate) to dobutamine for 100 ml total

- At this dilution an infusion rate of 1 ml/hr provides 1 µg/kg/min
- Starting dose is 5 to 10 µg/kg/min (5 to 10 ml/hr)

1.10.5.5 If an Infusion Pump Is Not Available

- Use a 500-ml bag of D5W or 0.9% saline for diluent
- Use a pediatric drip set (60 drops/ml)
- Flow rate of 1 drop/sec = 1 ml/min
- Number of milliliters of dobutamine (12.5 mg/ml) to add to 500 ml of fluids (not bicarbonate) = body weight (kg) × 0.4

Flow rates for dobutamine based on this dilution

2.5 µg/kg/min	=	1 drop/4 sec
5 µg/kg/min	=	1 drop/2 sec
10 µg/kg/min	=	1 drop/sec

1.10.5.6 How the Dilution and Flow Rate Were Calculated

For convenience in setting the flow rate, make the highest administration rate of 10 µg/kg/min equal to 1 drop/sec.

With a pediatric drip set at 60 drops/ml, 1 drop/sec delivers 1 ml/min. Make this equal to 10 µg/kg/min. That is, 1 ml provides 10 µg/kg. A 500-ml bag provides a total of 5000 µg/kg = 5 mg/kg.

Calculate how much dobutamine to add to 500 ml as follows:

Dobutamine is 12.5 mg/ml
5 mg/kg ÷ 12.5 mg/ml = (5 ÷ 12.5) ml/kg

Therefore, for each kilogram of the animal's weight, the number of milliliters of dobutamine to add to 500 ml = 5 ÷ 12.5 = 0.4.

Adjust flow rate as required, according to the flow rates itemized previously.

1.11 DOPAMINE

Dopamine *Abbott Laboratories*

1.11.1 Approved for

- No veterinary species

1.11.2 Features

Effects are dose dependent, as follows.

- 0.5 to 2 µg/kg/min
  - Dopaminergic-receptor activation
  - Dilation of renal, mesenteric, coronary, intracerebral vessels
- 2 to 10 µg/kg/min
  - $Beta_1$ and dopaminergic receptor activation
  - Cardiac inotrope; increased organ perfusion, renal blood flow, and urine production
- 10 to 15 µg/kg/min
  - Alpha, $beta_1$, and dopaminergic receptor activation
  - Increased peripheral resistance, increased blood pressure, and increased cardiac output
  - Decreased renal and peripheral blood flow (because alpha effects override dopaminergic effects)

1.11.3 Uses

- Treatment of hypotension during anesthesia in critical cases (e.g., gastric dilatation and volvulus [GDV] in dogs)
- Improvement or maintenance of renal perfusion in patients with preexisting renal disease

1.11.4 Precautions

- Always dilute prior to use
- Preferable to use an infusion pump for administration in small animals
- Monitor ECG and blood pressure carefully during use

1.11.5 Doses

1.11.5.1 For Horses

Add 5 ml dopamine (40 mg/ml) to either 500 ml or 1 L of 0.9% saline or other IV solution (not bicarbonate) and drip slowly until effective.

1.11.5.2 For Smaller Animals

1.11.5.2.1 If using an infusion pump

For dopamine at 200 mg in 5 ml (40 mg/ml):

- Add 0.27 ml to 60 ml of 0.9% saline or other IV solution (not bicarbonate)

For dopamine at 80 mg/ml:

- Add 0.135 ml to 60 ml of 0.9% saline or other IV solution (not bicarbonate)
- Start at the lowest dose and adjust as necessary
- Effects are seen within approximately 2 to 5 minutes

Infusion rates for dopamine based on this dilution

3 µg/kg/min	=	1 ml/kg/hr
6 µg/kg/min	=	2 ml/kg/hr
9 µg/kg/min	=	3 ml/kg/hr
12 µg/kg/min	=	4 ml/kg/hr

1.11.5.3 How the Dilution Was Calculated

For convenience, use pump settings of ml/kg/hr instead of µg/kg/min. Dilute the drug so that the lowest dose rate (3 µg/kg/min) = 1 ml/kg/hr.

For dopamine supplied at 40 mg/ml, the lowest dose of 3 µg/kg/min = (3 × 60) µg/kg/hr = 180 µg/kg/hr. Make this dose equal to 1 ml/kg/hr. Therefore drug must be diluted so that 1 ml contains 180 µg (= 0.18 mg).

$$40\,\text{mg/ml} \div 0.18\,\text{mg/ml} = 222.2$$

Therefore the provided drug must be diluted by 222.2.

To end up with a 60-ml volume in the infusion syringe, calculate the following.

$$60\,\text{ml} \div 222.2 = 0.27\,\text{ml}$$

Therefore add 0.27 ml of dopamine to 60 ml of saline.

1.11.5.4 If an Infusion Pump Is Not Available

- Use a 500-ml bag of D5W or 0.9% saline for diluent (not bicarbonate)
- Use a pediatric drip set (60 drops/ml)

- Flow rate of 1 drop/sec = 1 ml/min
- Number of milliliters of dopamine (40 mg/ml) to add to 500 ml of fluids (not bicarbonate) = body weight (kg) ÷ 8

Flow rates for dopamine based on this dilution

2.5 µg/kg/min	=	1 drop/4 sec
5 µg/kg/min	=	1 drop/2 sec
10 µg/kg/min	=	1 drop/sec

1.11.5.5 How the Dilution and Flow Rate Were Calculated

For convenience in setting the flow rate, make the highest administration rate of 10 µg/kg/min equal to 1 drop/sec. With a pediatric drip set at 60 drops/ml, 1 drop/sec delivers 1 ml/min. Make this equal to 10 µg/kg/min. That is, 1 ml provides 10 µg/kg. A 500-ml bag provides a total of 5000 µg/kg = 5 mg/kg.

Calculate how much dopamine to add to 500 ml as follows.

Dopamine is 40 mg/ml
5 mg/kg ÷ 40 mg/ml = (5 ÷ 40) ml/kg

Therefore for each kilogram of the animal's weight, the number of milliliters of dopamine that should be added to 500 ml = 5 ÷ 40 = ⅛

Adjust flow rate as required, according to the flow rates itemized previously.

1.12 DOXAPRAM

Dopram *Fort Dodge Laboratories*

1.12.1 Approved for

- Dogs, cats, and horses

1.12.2 Features

- General CNS stimulant that affects all levels of the CNS
- Produces respiratory stimulation mediated through the peripheral carotid chemoreceptors and the central respiratory centers in the medulla
- Onset of respiratory stimulation usually occurs in 20 to 40 seconds, with peak effect at 1 to 2 minutes
- Duration of effect varies from 5 to 12 minutes
- Respiratory stimulant action is manifested by an increase in tidal volume and respiratory rate

1.12.3 Uses

- Respiratory stimulant
- Facilitation of laryngeal examination
- Resuscitation of neonatal animals after dystocia or cesarean section

1.12.4 Precautions

- Should not be used as a substitute for mechanical ventilation

- Patients should be assessed for causes of respiratory depression, and primary disorder should be treated
- Can stimulate epinephrine release
- Not to be used in patients with CNS disease (increased intracranial pressure, epilepsy), hyperthyroidism, pheochromocytoma

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1.12.5 Doses

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Doses of Doxapram by Species

Species	IV (mg/kg)
Horses	0.5–1
Cattle	5–10
Sheep	5–10
Goats	5–10
Pigs	5–10
Dogs	1–5
Cats	5–10
Rabbits	2–5
Ferrets	2–5

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1.13 DURAMORPH

Duramorph (Morphine) *Baxter Healthcare Corporation*

1.13.1 Approved for

- No veterinary species

1.13.2 Features

- DEA Schedule II controlled substance
- Preservative-free morphine
- Acts at opiate receptors in substantia gelatinosa of spinal cord
- Onset 30 to 60 minutes
- Duration up to 24 hours

1.13.3 Uses

- Intended for epidural and spinal administration

1.13.4 Precautions

- Respiratory depression, pruritus, urinary retention, or constipation may occur
- Naloxone should be available for treatment of adverse effects
- Drug must be handled in a sterile fashion
- Filter needle should be used to remove drug from glass ampule, as glass shards may be transferred into the solution when vial is broken open
- Unused drug must be discarded as no preservative is present

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1.13.5 Doses

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Doses of Duramorph by Species

Species	Epidural* (mg/kg)
Horses	0.1
Cattle	0.1
Sheep	0.1
Goats	0.1
Pigs	0.1
Dogs	0.1–0.2
Cats	0.1
Rabbits	0.1
Ferrets	0.1

* For spinal administration (into CSF): decrease epidural dose by 50%.

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1.14 EDROPHONIUM

Enlon — *Baxter Healthcare Corporation*
Abbott Laboratories

1.14.1 Approved for

- No veterinary species

1.14.2 Features

- Short duration, rapidly acting parasympathomimetic
- Inactivates the enzyme acetylcholinesterase by combining with it in a reversible manner
- Prevents hydrolysis of ACh and allows the accumulation of the neurotransmitter
- Accumulation of ACh at cholinergic receptor sites leads to the resumption of normal cholinergic transmission at the myoneural junction

- Effect is manifested within 30 to 60 seconds after injection
- Duration of action is approximately 20 minutes

1.14.3 Uses

- Reversal of nondepolarizing neuromuscular blocking agents
- Diagnosis of myasthenia gravis

1.14.4 Precautions

- Bradycardia can result from action on cardiac muscarinic receptors; administer concurrent anticholinergic (atropine or glycopyrrolate)
- Duration of action shorter than nondepolarizing neuromuscular agents; may need to readminister
- To assess adequacy of muscle function
  - Use peripheral nerve stimulator
  - Assess inspiratory effort when endotracheal tube is occluded
  - Measure tidal volume with a volumeter
- Exercise caution when administering to patients with bronchial asthma or cardiac dysrhythmias

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- Exercise caution when administering to patients with symptoms of myasthenic weakness who are also being given anticholinesterase drugs

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1.14.5 Doses

Doses of Edrophonium by Species

Species	IV (mg/kg)
Horses	0.5–1
Cattle	0.5–1
Sheep	0.5–1
Goats	0.5–1
Pigs	0.5–1
Dogs	0.5–1
Cats	0.5–1
Rabbits	0.5–1
Ferrets	0.5–1

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1.15 EMLA CREAM

EMLA *Astra Zeneca Pharmaceuticals*

1.15.1 Approved for

- No veterinary species

1.15.2 Features

- Acronym for *E*utectic *M*ixture of *L*ocal *A*nesthetics
- Emulsion in which the oil phase is a eutectic* mixture of the local anesthetics lidocaine and prilocaine in a ratio of 1:1 by weight
- A eutectic mixture has a melting point below room temperature; therefore both local anesthetics exist as liquid oils rather than as crystals
- The high concentration of the local anesthetics in a high water–content vehicle promotes the transdermal spread of the anesthetic ingredients
- When EMLA Cream is applied to normal intact skin for an hour, the skin at the application site becomes numb because of drug penetration and localized sodium channel blockage, which prevents nerve conduction
- Anesthetic depth of 3 mm is achieved after 60 minutes and increases 1 mm per 30 minutes up to 5 mm at 120 minutes

* Of greatest fusibility; easily melted or dissolved.

1.15.3 Uses

- Regional anesthesia of small area (e.g., for small, superficial mass removal or skin biopsy)
- Facilitation of venous and arterial cannulation (e.g., rabbit pinna), routine injections, and repair of minor lacerations

1.15.4 Precautions

- Exercise caution in patients with broken skin, because absorption of lidocaine and prilocaine is much greater through nonintact skin

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- Do not use on mucous membranes or in or near eyes
- Contraindicated in patients with methemoglobinemia
- Contraindicated in patients with a known history of sensitivity to local anesthetics of the amide type (e.g., lidocaine, prilocaine, bupivacaine)

1.15.5 Dose and Technique

- Before procedure squeeze a dollop of EMLA Cream directly onto the skin and thickly cover the area
- Cover with an occlusive, nonporous dressing or plastic wrap
- Seal edges only, ensuring that there is no leakage of cream
- Be sure to allow EMLA Cream to remain in a thick layer
- Remove the thin paper frame and seal the edges of the dressing onto the skin
- Record the time
- EMLA Cream may be left in place for up to 3 hours without diminishment of its effectiveness
- Make certain EMLA Cream remains undisturbed
- Care should be taken to prevent ingestion of EMLA Cream or the occlusive dressing
- Immediately before the procedure (at least 60 minutes after EMLA Cream has been applied), remove the dressing and cream
- Clean entire area as usual and begin procedure

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1.16 EPHEDRINE

Ephedrine *Bedford Laboratories*

1.16.1 Approved for

- No veterinary species

1.16.2 Features

- Noncatecholamine sympathomimetic
- Acts directly on $beta_1$ and $beta_2$ receptors and indirectly on $alpha_1$ receptors by causing norepinephrine release from the presynaptic vesicles
- Increases cardiac output, stroke volume, and arterial blood pressure
- Bronchodilator
- Onset—30 seconds
- Duration—5 to 15 minutes

- Inexpensive and simple to administer; can be given as an IV bolus rather than as a continuous infusion as is required with many inotropic drugs

1.16.3 Uses

- Treatment of low blood pressure resulting from vasodilation
- Vasopressor of choice in pregnant patients as it does not reduce placental blood flow

1.16.4 Precautions

- Monitor ECG for arrhythmias
- Possible arrhythmias if used with halothane
- May cause tachycardia and hypertension
- May cause CNS excitement and increase the anesthetic requirement

1.16.5 Doses

- The same dose of ephedrine can be repeated several times if hypotension persists or recurs a few minutes after the initial dose
- However, repeated doses are less effective (i.e., ephedrine demonstrates tachyphylaxis) 33

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Doses of Ephedrine by Species

Species	IV (mg/kg)
Horses	0.04–0.06
Cattle	0.02–0.06
Sheep	0.02–0.06
Goats	0.02–0.06
Pigs	0.04–0.08
Dogs	0.05–0.2
Cats	0.05–0.1
Rabbits	0.04–0.08
Ferrets	0.04–0.08

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1.17 EPINEPHRINE

Epinephrine	*Butler Company*
Epinject	*Vetus Animal Health*

1.17.1 Approved for

- Horses, cattle, sheep, swine, dogs, cats

1.17.2 Features

- Sympathomimetic catecholamine
- Stimulation of alpha, $beta_1$, and $beta_2$ receptors
- Increases heart rate, myocardial contractility, and cardiac output
- Increases arterial blood pressure (systolic more than diastolic) by means of arterial vasoconstriction
- Bronchodilation

1.17.3 Uses

- During cardiac arrest (asystole, electromechanical dissociation)—restoration of cardiac rhythm, increase in venous return and cardiac output
- Vasopressor for patients with impaired venous return or shock, or after resuscitation
- Severe acute allergic reactions and anaphylactic shock
- Infiltration of tissue to delay absorption of drugs, including local anesthetics
- Topically, control of hemorrhage

1.17.4 Precautions

- Monitor ECG for arrhythmias
- May be deactivated by alkaline solutions (lactated Ringer's solution [LRS]; sodium bicarbonate)
- Epinephrine is available in two strengths—1:1000, which is 1 mg/ml, and 1:10,000, which is 0.1 mg/ml

1.17.5 Doses

- It has been reported that higher doses of epinephrine (0.2 mg/kg) may be more effective than the previously recommended doses (0.02 mg/kg)

- The higher doses tend to improve cerebral blood flow but also may predispose to ventricular fibrillation
- Current Advanced Cardiac Life Support (ACLS) guidelines state that administration of epinephrine may be repeated every 3 to 5 minutes

Doses of Epinephrine by Species

Species	IV (mg/kg)	IM, SC (mg/kg)
Horses	0.01–0.2	0.2
Cattle	0.02–0.2	0.2
Sheep	0.02–0.2	0.2
Goats	0.02–0.2	0.2
Pigs	0.02–0.2	0.2
Dogs	0.02–0.2	0.2
Cats	0.02–0.2	0.2
Rabbits	0.02–0.2	0.2
Ferrets	0.02–0.2	0.2

1.17.5.1

Constant-Rate Infusion Dose

0.2–1 µg/kg/min in all species

1.17.5.1.1

If using an infusion pump

- Addition of 0.72 mg (0.72 ml) of epinephrine to 60 ml of saline or other nonalkaline IV solution results in a final concentration of 0.012 mg/ml
- For epinephrine at 0.012 mg/ml (12 µg/ml):
  - Add 0.72 ml to 60 ml of 0.9% saline or other nonalkaline (D5W or 0.9% saline) IV solution
  - Start at the lowest dose and adjust as necessary
  - Effects are seen within 1 minute

Infusion rates for epinephrine based on this dilution

0.2 µg/kg/min = 1 ml/kg/hr
0.4 µg/kg/min = 2 ml/kg/hr
0.5 µg/kg/min = 2.5 ml/kg/hr
1 µg/kg/min = 5 ml/kg/hr

1.17.5.2

How the Dilution Was Calculated

Epinephrine is supplied at two concentrations: 1 mg/ml (1:1000) and 0.1 mg/ml (1:10,000).

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For convenience, use pump settings of ml/kg/hr instead of µg/kg/min. Dilute the drug so that the lowest dose rate (0.2 µg/kg/min) = 1 ml/kg/hr. The lowest dose of 0.2 µg/kg/min = (0.2 × 60) µg/kg/hr = 12 µg/kg/hr. Make this dose equal to 1 ml/kg/hr. Therefore drug must be diluted so that 1 ml contains 12 µg.

Use the following calculations for epinephrine at 1:1000 (which is 1 mg/ml, or 1000 µg/ml).

Epinephrine concentration ÷ desired concentration = Factor for dilution of drug
1000 µg/ml ÷ 12 µg/ml = 83.3

Therefore the provided drug must be diluted by 83.3.

To end up with a 60-ml volume in the infusion syringe, calculate as follows.

$$60\,\text{ml} \div 83.3 = 0.72\,\text{ml}$$

Therefore add 0.72 ml of epinephrine to 60 ml of saline.

1.17.5.3 If an Infusion Pump Is Not Available

- Use a 500-ml bag of nonalkaline IV solution (D5W or 0.9% saline) for diluent
- Use a pediatric drip set (60 drops/ml)
- Flow rate of 1 drop/sec = 1 ml/min
- Number of milliliters of epinephrine (1 mg/ml) to add to 500-ml bag = body weight (kg) ÷ 4

Flow rates for epinephrine based on this dilution

$$\begin{aligned} 0.25\,\mu\text{g/kg/min} &= 1\text{ drop/2 sec} \\ 0.5\,\mu\text{g/kg/min} &= 1\text{ drop/sec} \\ 1\,\mu\text{g/kg/min} &= 2\text{ drops/sec} \end{aligned}$$

1.17.5.4 How the Dilution and Flow Rate Were Calculated

For convenience with setting the flow rate, make the administration rate of 0.5 µg/kg/min equal to 1 drop/sec. With a pediatric drip set at 60 drops/ml, 1 drop/sec delivers 1 ml/min—that is, 1 ml provides 0.5 µg/kg. A 500-ml bag provides a total of 500 minutes × 0.5 µg/kg/min = 250 µg/kg = 0.25 mg/kg. 37 38

If using epinephrine concentration of 1:1,000 (1 mg/ml), calculate how much epinephrine to add to 500 ml as follows, where BW = body weight.

$$\frac{\text{BW} \times 0.5\,\mu\text{g/kg/min} \times 500\,\text{min}}{1\,\text{mg/ml}} = \frac{\text{BW} \times 0.25\,\text{mg/kg}}{1\,\text{mg/ml}} = \text{BW} \times 0.25 = \frac{\text{BW}}{4}$$

For example, in the case of a 20-kg animal, add 5 ml of 1:1000 epinephrine to a 500-ml bag of fluids and run at 1 drop/sec to deliver 0.5 µg/kg/min. 38

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1.18 ETOMIDATE

Amidate *Abbott Laboratories*

1.18.1 Approved for

- No veterinary species

1.18.2 Features

- IV, ultra–short-acting, nonbarbiturate hypnotic drug
- Onset—15 to 30 seconds

- Duration—5 to 15 minutes
- Undergoes rapid hepatic metabolism, resulting in rapid recovery and lack of accumulation when used in repeated boluses or as an infusion
- Produces no change in heart rate, arterial blood pressure, or myocardial performance
- Lowers intraocular and intracranial pressure, and lowers the rate of cerebral oxygen use
- Provides the most cardiovascular stability compared with all other IV anesthetic agents
- Most expensive induction agent

1.18.3 Uses

- Anesthetic induction agent
- Induction agent of choice in patients with cardiovascular disease

1.18.4 Precautions

- Etomidate may induce transient respiratory depression and apnea
- Sneezing, retching, excitement, or myoclonic twitching can be observed during induction (these side effects can be minimized with premedication or concurrent administration of a benzodiazepine)
- Inhibits adrenocortical function (inhibits corticosteroidogenesis directly) for up to 6 hours after a single injection
- Supplemental steroid administration should be considered in patients on chronic oral corticosteroid therapy

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- Hemolysis and hematuria reported in dogs, cats, and rabbits after long-term (greater than 1 hour) IV infusion (etomidate is insoluble and unstable in neutral water, so it is prepared in propylene glycol 35% by volume)

1.18.5 Doses

Doses of Etomidate by Species

Species	IV (mg/kg)
Horses	NR
Cattle	NR
Sheep	0.5–1
Goats	0.5–1
Pigs	0.5–1
Dogs	1–3
Cats	1–3
Rabbits	0.5–2
Ferrets	0.5–2

NR, Not recommended.

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1.19 FENTANYL INJECTABLE

Sublimaze	*Janssen Pharmaceutica*
Fentanyl	*Abbott Laboratories*

1.19.1 Approved for

- No veterinary species

1.19.2 Features

- DEA Schedule II controlled substance
- Short-acting pure opiate agonist
- Onset—1 minute
- Duration—15 to 30 minutes
- Minimal cardiovascular effects, except bradycardia
- Respiratory depressant

1.19.3 Uses

- Induction of anesthesia
- Maintenance of anesthesia of short duration
- Supplemental analgesia and narcosis via constant-rate infusion during general or regional anesthesia
- Analgesia in the immediate postoperative period

1.19.4 Precautions

- Respiratory depression may result
- Concurrent inhalant anesthetic administration requires intermittent positive pressure ventilation as respiratory depression may be severe
- Exercise caution in patients with head trauma or increased intracranial pressure (hypoventilation can increase intracranial pressure)
- Bradycardia may result and may be prevented by pretreatment with anticholinergic
- Observe patient for agitation; consider administration of sedative
- Monitor for signs of ileus, constipation
- Reverse with naloxone

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1.19.5 Doses

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Doses of Fentanyl Injectable by Species

Species	IV (µ/kg)	IV during Anesthesia (µ/kg/hr)
Horses*	NA	1–3
Cattle*	NA	NA
Sheep*	1–6	1–5
Goats*	1–6	1–5
Pigs*	30–50	50–100
Dogs*	3–10	3–10
Cats*	3–6	3–6
Rabbits*	3–6	3–6
Ferrets	NA	NA

NA, Not appropriate.

* These species should not be premedicated with this agent alone. Best used in combination with sedative agent.

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1.20 FENTANYL TRANSDERMAL PATCH

Duragesic	*Janssen Pharmaceutica*
Fentanyl	*Abbott Laboratories*

1.20.1 Approved for

- No veterinary species

1.20.2 Features

- DEA Schedule II controlled substance
- Short-acting pure opiate agonist
- Provides continuous systemic delivery of fentanyl
- Patch is a rectangular, transparent unit containing fentanyl and a protective membrane that controls drug release
- Drug diffuses from patch into the subcutaneous tissues and is then absorbed into the systemic circulation at a nearly constant amount per unit of time
- Patch comes in four strengths or sizes: 25, 50, 75, 100 µg/hr
- Onset—12 to 24 hours
- Duration—3 days (5 days in cats)

1.20.3 Uses

- Analgesia during surgery—place 12 to 24 hours preoperatively
- Postoperative analgesia
- Long-term use in cancer, arthritis, or other chronic pain conditions

1.20.4 Precautions

- Patch must be applied to clean, dry, hair-free, unbroken skin
- Do not cut patch, as it renders controlled drug delivery impossible
- Do not use an occlusive bandage over the patch to keep it in place; this causes a faster delivery of fentanyl and possible overdose
- Direct heat (e.g., hot water bottle) can increase absorption
- Respiratory depression may result

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- Exercise caution in patients with head trauma or increased intracranial pressure (hypoventilation can increase intracranial pressure)
- Observe patient for agitation; consider administration of sedative
- Monitor for signs of ileus, constipation
- Side effects are completely reversible with opiate antagonist (naloxone)

- Ensure that patient cannot ingest patch
- If sending patient home with patch, ensure that owner is fully aware of side effects and cautions; recommend that owner return used patch to clinic for proper disposal

1.20.5 Doses

Doses of Fentanyl Transdermal by Species

Species	Patch Size (g/hr)
Horses	100/68 kg
Cattle	100/68 kg
Sheep	NR
Goats	NR
Pigs	NR
Dogs	10 kg: 25
	10–20 kg: 50
	20–30 kg: 75
	>30 kg: 100
Cats	25
Rabbits	25
Ferrets	NR

NR, Not recommended.

1.21 FLUMAZENIL

Romazicon *Roche Pharmaceuticals*

1.21.1 Approved for

- No veterinary species

1.21.2 Features

- Benzodiazepine receptor antagonist
- Antagonizes the actions of benzodiazepines on the CNS; competitively inhibits activity at the benzodiazepine recognition site on the GABA-benzodiazepine receptor complex
- Does not antagonize the CNS effects of drugs that affect GABA-ergic neurons by means other than the benzodiazepine receptor (including ethanol, barbiturates, or general anesthetics) and does not reverse the effects of opioids
- Onset of reversal is usually evident within 1 to 2 minutes after injection
- Within 3 minutes 80% response is reached; peak effect occurs at 6 to 10 minutes

- Duration and degree of reversal are related to the plasma concentration of the sedating benzodiazepine as well as the dose of flumazenil given (duration of reversal may be as short as 5 minutes or as long as 1 hour)

1.21.3 Uses

- Complete or partial reversal of the sedative effects of benzodiazepines used for induction or maintenance of general anesthesia
- Management of benzodiazepine overdose

1.21.4 Precautions

- Administer the smallest amount of flumazenil that is effective, because it takes 6 to 10 minutes for any single dose of flumazenil to reach full effect
- Use caution in patients who have been given a benzodiazepine for control of a potentially life-threatening condition (e.g., intracranial pressure or status epilepticus)

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1.21.5 Doses

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Doses of Flumazenil by Species

Species	IV (mg/kg)
Horses	0.1–1
Cattle	0.1–1
Sheep	0.1–1
Goats	0.1–1
Pigs	0.1–1
Dogs	0.1–1
Cats	0.1–1
Rabbits	0.1–1
Ferrets	0.1–1

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1.22 FUROSEMIDE

Furosemide	*Butler Company*
EquiPhar	*Vedco, Inc.*
Furoject	*Vetus Animal Health*

1.22.1 Approved for

- Dogs, cats, cattle, horses

1.22.2 Features

- Loop diuretic

- Inhibits the reabsorption of sodium and chloride in the proximal and distal tubules as well as the ascending loop of Henle
- Promotes excretion of sodium, chloride, calcium and, to a lesser degree, potassium and bicarbonate ions
- Onset—10 minutes
- Peak effect in 30 minutes; duration of effect is 4 to 5 hours

1.22.3 Uses

- Reduction of pulmonary and peripheral edema
- Reduction of edema associated with congestive heart failure
- Reduction of venous return (preload)
- Reduction of central venous pressure
- Treatment of hypercalcemia
- Acidification of urine

1.22.4 Precautions

- Can cause fluid and electrolyte depletion leading to hypovolemia, dehydration, hypotension
- Can lead to metabolic alkalosis, hypokalemia, hypomagnesemia, hypocalcemia, hyponatremia
- Use with extreme caution in patients with preexisting prerenal azotemia, impaired hepatic function, electrolyte abnormalities, or fluid depletion
- Monitor fluid and electrolyte status frequently
- Do not use in patients with urinary blockage

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- Pain and irritation may occur if injected IM
- Furosemide may impair kidney function when administered together with aspirin or other nonsteroidal antiinflammatory drugs (NSAIDs)
- Physically incompatible with dobutamine, epinephrine, gentamicin, tetracyclines, local anesthetics, opiates

1.22.5 Doses

Doses of Furosemide by Species

Species	IV (mg/kg)
Horses	1–4
Cattle	0.5–1
Sheep	2–4
Goats	2–4
Pigs	2–4
Dogs	1–4
Cats	1–4
Rabbits	2–5
Ferrets	2–5

1.23 GLYCOPYRROLATE

Robinul — *Fort Dodge Laboratories*
Baxter Healthcare Corporation

1.23.1 Approved for

- Dogs and cats

1.23.2 Features

- Synthetic quaternary ammonium compound
- Muscarinic receptor antagonist
- Reduces volume and decreases acidity of gastric secretions
- Reduces pharyngeal, tracheal, bronchial secretions
- Antagonizes muscarinic symptoms (bradycardia, bronchospasm, intestinal hypermotility) induced by anticholinesterases administered during reversal of neuromuscular blockade
- Does not cross blood-brain barrier (unlike atropine); no pupillary dilation
- Less arrhythmogenic than atropine
- Onset—1 minute
- Duration—2 to 4 hours

1.23.3 Uses

- Premedicant for controlling salivation

- Prevention and treatment of bradycardia caused by vagal reflexes, opiates, anticholinesterases
- Anticholinergic of choice for rabbits because of limited duration of atropine in this species
- Treatment of diarrhea and bowel or bladder spasm

1.23.4 Precautions

- Anticholinergics are contraindicated in horses unless a life-threatening bradycardia (or asystole) is present, as routine use may initiate ileus and colic

1.23.5 Doses

Doses of Glycopyrrolate by Species

Species	IV (mg/kg)	IM, SC (mg/kg)
Horses*	0.0025–0.005	NA
Cattle*	0.0025–0.005	NA
Sheep	0.005–0.01	0.01–0.02
Goats	0.005–0.01	0.01–0.02
Pigs	0.005–0.01	0.01–0.02
Dogs	0.005–0.01	0.01–0.02
Cats	0.005–0.01	0.01–0.02
Rabbits	0.005–0.01	0.01–0.05
Ferrets	0.005–0.01	0.01–0.02

NA, Not appropriate.

* These species are administered glycopyrrolate only if a life-threatening bradycardia (or asystole) occurs.

1.24 GUAIFENESIN

GuaifenesinButler Company

1.24.1 Approved for

- Horses not intended for food

1.24.2 Features

- Also known as glyceryl guaiacolate or GG
- Centrally acting skeletal muscle relaxant
- Acts by depressing internuncial neurons of the subcortical areas of the brain
- Produces mild sedation but is not an anesthetic
- Relaxes laryngeal and pharyngeal muscles

- Expectorant
- Onset—2 minutes
- Duration—10 to 30 minutes

1.24.3 Uses

- Primarily an adjunct to induction of anesthesia in large animals (horses and cattle)
- Maintenance of muscle relaxation as an adjunct to other injectable anesthetic agents for short procedures (up to 60 minutes)
- Guaifenesin improves ketamine anesthesia in the horse and provides more muscle relaxation than is produced by ketamine alone

1.24.4 Precautions

- Respiratory rate increases and tidal volume decreases; degree of ventilatory depression is dose related
- Guaifenesin produces minimal cardiovascular changes; however, guaifenesin can produce severe hypotension with large doses
- Solutions greater than 10% of guaifenesin may produce hemolysis
- Solution may precipitate, particularly in cold temperatures and especially if barbiturate has been added; solution should not be used if precipitate is present; warming solution may dissolve precipitate

- Duration in male horses is 1½ times that in mares; no difference exists in dosage because of sex
- A large volume must be administered as quickly as possible; either a large venous catheter and wide-bore infusion set must be used, or the bottle must be pressurized
- Solutions of guaifenesin irritate tissues; the higher the concentration used, the greater the tissue damage from perivascular extravasation; a 5% solution causes some irritation, and 7.5% and 10% solutions cause severe irritation; immediate infiltration of 200 to 300 ml of saline in the area of perivascular injection may prevent tissue necrosis; a catheter should always be used to avoid perivascular injection
- Thrombophlebitis may occur after routine IV administration

1.24.5 Doses

IV use *only*.

Doses of Guaifenesin by Species

Species	IV (mg/kg)
Horses*	50–100
Cattle*	50–100
Sheep*	30–90
Goats*	30–90
Pigs*	30–90
Dogs	30–90
Cats	NA
Rabbits	NA
Ferrets	NA

* Commonly administered IV until muscle relaxation occurs, followed by IV administration of ketamine 1.1 mg/kg for induction of anesthesia.

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1.25 HALOTHANE

Halothane *Abbott Laboratories*

1.25.1 Approved for

- Dogs, cats, nonfood animals

1.25.2 Features

- Potent inhalant agent for general anesthesia
- Precision vaporizer required
- Relatively rapid induction and recovery, but slower than seen with isoflurane or sevoflurane
- No analgesia
- Decreases cardiac output and produces vasodilation and hypotension
- Sensitizes myocardium to catecholamine-induced arrhythmias
- Causes less respiratory depression than does isoflurane or sevoflurane
- Triggers malignant hyperthermia in susceptible patients
- Decreases tear production in horses to approximately 60% of normal within 30 minutes; tear production returns to normal in 3 hours
- Depresses temperature regulation
- Increases cerebral blood flow and intracranial pressure

- May cause hepatic injury if used repeatedly

1.25.3 Uses

- Induction of anesthesia in chamber or by mask (e.g., in cats, exotics, neonates), but occurs more slowly than with isoflurane or sevoflurane
- Induction via nasotracheal tube in neonatal foals, but occurs more slowly than with isoflurane or sevoflurane
- Maintenance of general anesthesia in all species

1.25.4 Precautions

- Do not use in patients with head trauma or possible brain tumor

- Do not use in patients susceptible to malignant hyperthermia
- Use cautiously in patients with hepatic or renal disease
- Monitor patients closely, and adjust setting as required
- Avoid exposing pregnant staff members to vapor

1.25.5 Doses

- For anesthetic maintenance, aim for end-tidal concentration of 1.5 × MAC
- Various factors affect MAC, and these must be taken into account when determining the optimum setting to use (see discussions of MAC and of Consumption of Halothane in Appendix A)

MAC Values for Halothane by Species

Species	MAC Value	1.5 × MAC
Horses	0.88	1.32
Cattle	0.76*	1.14
Sheep	0.97	1.46
Goats	0.96	1.44
Pigs	0.94	1.41
Dogs	0.87	1.31
Cats	1.14	1.71
Rabbits	1.39	2.09
Ferrets	1.01	1.52

* Calves.

1.26 HYDROMORPHONE

Hydromorphone	*Baxter Healthcare Corporation* *Abbott Laboratories*

1.26.1 Approved for

- No veterinary species

1.26.2 Features

- DEA Schedule II controlled substance
- Pure opiate agonist acting primarily on mu receptors
- Analgesia
- Bradycardia and increased vagal tone (central effect)
- Respiratory depression
- Panting may occur in dogs
- Sedation usually occurs, but euphoria may occur in some patients
- Decreased gut motility, especially with chronic use
- Vomiting and defecation may occur initially
- Urine retention
- Hypothermia
- Occasionally may cause mild histamine release after IV injection
- Metabolized in liver, mainly by glucuronidation (slower metabolism in cats)

1.26.3 Uses

- Premedication of dogs and cats
- Analgesic for IV use during general anesthesia for painful surgical procedures
- Postoperative analgesia in dogs and cats

1.26.4 Precautions

- Do not use in patients that are hypersensitive to opiates
- Do not use in patients with gut obstruction (e.g., foreign body, GDV)
- Do not use in patients with increased intracranial pressure
- Use cautiously in patients with bradyarrhythmias

- Use cautiously in patients with renal or hepatic disease or adrenal insufficiency
- Metabolism may be slower in cats because of lack of glucuronidase enzyme
- Cats may require a concomitant tranquilizer to prevent euphoric behavioral effects
- Reverse with naloxone

1.26.5 Doses

Doses of Hydromorphone by Species

Species	IV (mg/kg)	IM, SC (mg/kg)
Horses	NA	NRP
Cattle	NA	NRP
Sheep	NA	NRP
Goats	NA	NRP
Pigs	NA	NRP
Dogs	0.1–0.4	0.1–0.4
Cats	0.05–0.1	0.05–0.1
Rabbits	NRP	NRP
Ferrets	NRP	NRP

NA, Not appropriate; *NRP*, not reported.

1.27 ISOFLURANE

IsoFlo *Abbott Laboratories*
Iso-Thesia *Vetus Animal Health*

1.27.1 Approved for

- Dogs, cats, horses not intended for food

1.27.2 Features

- Potent inhalant agent for general anesthesia
- Precision vaporizer required
- Halothane vaporizer can be used (saturated vapor pressures are similar) but is not recommended
- Rapid induction and recovery (intermediate, between those of halothane and sevoflurane)
- No analgesia
- Less myocardial depression than occurs with halothane or sevoflurane
- Less sensitization of myocardium to catecholamine-induced arrhythmias
- Causes vasodilation and hypotension

- Not irritating to airway but causes respiratory depression
- Increases cerebral blood flow and intracranial pressure
- Depression of temperature regulation
- May trigger malignant hyperthermia in susceptible species or breeds

1.27.3 Uses

- Induction of anesthesia in chamber or by mask (e.g., in cats, exotics, neonates)
- Induction via nasotracheal tube in neonatal foals
- Maintenance of general anesthesia in all species

1.27.4 Precautions

- Do not use in patients with head trauma or possible brain tumor
- Do not use in patients susceptible to malignant hyperthermia
- Monitor patients closely and adjust setting as required
- Avoid exposing pregnant staff to vapor

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1.27.5 Doses

- For anesthetic maintenance, aim for end-tidal concentration of 1.5 × MAC
- Various factors affect MAC, and these must be taken into account when determining the optimum setting to use (see discussions of MAC and Isoflurane in Appendix A).

MAC Values for Isoflurane by Species

Species	MAC Value	1.5 × MAC
Horses	1.31	1.97
Cattle	NRP	NRP
Sheep	1.58	2.4
Goats	1.29	1.9
Pigs	1.75	2.6
Dogs	1.28	1.9
Cats	1.63	2.5
Rabbits	2.05	3.1
Ferrets	1.52	2.3

NRP, Not reported.

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1.28 ISOPROTERENOL

Isuprel *Abbott Laboratories*

1.28.1 Approved for

- No veterinary species

1.28.2 Features

- Beta$_1$ and beta$_2$ agonist
- Increases heart rate, myocardial contractility, and cardiac output
- Dilates bronchi by relaxing smooth muscle

1.28.3 Uses

- To increase heart rate (e.g., in complete heart block)
- Treatment of acute bronchial constriction

1.28.4 Precautions

- Monitor ECG for arrhythmias
- Do not use with other sympathomimetic drugs

1.28.5 Doses

1.28.5.1 If Using an Infusion Pump

For isoproterenol at 0.2 mg/ml:

- Add 0.36 ml to 60 ml of 0.9% saline or other IV solution
- Start at the lowest dose and adjust as necessary
- Effects are seen within 1 or 2 minutes

Infusion rates for isoproterenol based on this dilution

0.02 µg/kg/min	=	1 ml/kg/hr
0.04 µg/kg/min	=	2 ml/kg/hr
0.06 µg/kg/min	=	3 ml/kg/hr
0.08 µg/kg/min	=	4 ml/kg/hr

1.28.5.2 How the Dilution Was Calculated

For convenience, use pump settings of ml/kg/hr instead of µg/kg/min. Dilute the drug so that the lowest dose rate (0.02 µg/kg/min) = 1 ml/kg/hr. Isoproterenol is supplied at 0.2 mg/ml = 200 µg/ml. The lowest dose of 0.02 µg/kg/min = (0.02 × 60) µg/kg/hr = 1.2 µg/kg/hr. Make this dose equal to 1 ml/kg/hr. Therefore drug must be diluted so that 1 ml contains 1.2 µg.

$$200\,\mu g/ml \div 1.2\,\mu g/ml = 166.6$$

Therefore the provided drug must be diluted by 166.6.

To end up with a 60-ml volume in the infusion syringe:

$$60\ ml \div 166 = 0.36\ ml$$

Therefore add 0.36 ml of isoproterenol to 60 ml of saline.

1.28.5.3 If an Infusion Pump Is Not Available

- Use a 500-ml bag of D5W or 0.9% saline for diluent
- Use a pediatric drip set (60 drops/ml)
- Flow rate of 1 drop/sec = 1 ml/min
- Number of milliliters of isoproterenol (0.2 mg/ml) to add to 500 ml of fluids = body weight (kg) × 0.2

Flow rates for isoproterenol based on this dilution

$$\begin{aligned} 0.02\,\mu g/kg/min &= 1\ drop/4\ sec \\ 0.04\,\mu g/kg/min &= 1\ drop/2\ sec \\ 0.06\,\mu g/kg/min &= 3\ drops/4\ sec \\ 0.08\,\mu g/kg/min &= 1\ drop/sec \end{aligned}$$

1.28.5.4 How the Dilution and Flow Rate Were Calculated

For convenience in setting the flow rate, make the highest administration rate of 0.08 µg/kg/min equal to 1 drop/sec. With a pediatric drip set at 60 drops/ml, 1 drop/sec delivers 1 ml/min. Make this equal to 0.08 µg/kg/min—that is, 1 ml provides 0.08 µg/kg. A 500-ml bag provides a total of 40 µg/kg = 0.04 mg/kg.

Calculate how much isoproterenol to add to 500 ml as follows.

$$\text{Isoproterenol} = 0.2\ mg/ml$$
$$0.04\,mg/kg \div 0.2\,mg/ml = (0.04 \div 0.2)\ ml/kg$$

Therefore for each kilogram of the animal's body weight, the number of milliliters of isoproterenol to add to 500 ml = (0.04 ÷ 0.2) = 0.2.

Adjust flow rate as required according to the flow rates itemized previously.

1.29 KETAMINE

Ketaset	*Fort Dodge Laboratories*
Ketalar	*Abbott Laboratories*
Keta-Thesia	*Vetus Animal Health*

1.29.1 Approved for

- Cats, subhuman primates

1.29.2 Features

- DEA Schedule III controlled substance
- Dissociative anesthetic that activates limbic system and depresses thalamoneocortical system, producing a cataleptic state
- Inhibition of GABA receptors
- Increased sympathetic tone
- Rapid onset and long duration
- Increased dosage prolongs duration but does not increase depth of anesthesia
- Excellent somatic analgesia but poor visceral analgesia
- Increased cardiac output, heart rate, pulmonary artery pressure, central venous pressure, and intraocular pressure
- No depression of laryngeal, pharyngeal, pinnal, or pedal reflexes
- Hypersalivation
- Increased muscle tone
- Slight hypothermia in cats
- Eyes remain open in cats
- Slow recovery when used alone, with possible vocalization and tremors

1.29.3 Uses

- Restraint for minor procedures (e.g., examination, wound dressing)
- Restraint of feral or aggressive cats
- Induction of general anesthesia in horses after premedication with other drugs

- Intermittent IV use in anesthetized horses to increase depth of anesthesia acutely

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- Most useful as an adjunct to other drugs for neuroleptanalgesia and anesthesia
- Intraoperative or postoperative analgesia when administered as a constant-rate infusion

1.29.4 Precautions

- Do not use in patients with head trauma or increased intracranial pressure
- Use very cautiously in patients with history of seizures
- Do not use in patients with open globe or increased intraocular pressure
- Do not use in patients with tachyarrhythmias, hypertension, heart disease, or heart failure
- Do not use in patients susceptible to malignant hyperthermia
- Not suitable alone for major surgery
- Not suitable alone for oral procedures
- Anticholinergics for controlling salivation may cause excessive tachycardia when ketamine has been used alone
- Protect cornea from drying or injury

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1.29.5 Doses

Doses of Ketamine by Species

Species	IV (mg/kg)	Infusion Rate (mg/kg/min)	IM, SC[a] (mg/kg)
Horses[b]	2.2	NA	NA
Cattle[b]	2	NA	NA
Sheep[c]	2–4	?	22
Goats[c]	2–4	NA	11
Pigs[c,d]	2–4	NA	11
Dogs[c,e]	10	0.1–0.6	11–22
Cats[f]	10 (Induction)	0.1–0.6	7–10 (Premedication) 10–30 (Restraint)
Rabbits[c]	10–15	NA	20–40
Ferrets[c]	10	NA	10–30

NA, Not appropriate.

a IM route is preferred over SC route.

b Use only after sufficient premedication (e.g., with xylazine, diazepam, midazolam, guaifenesin).

c Best used with or after other drugs, (e.g., diazepam, midazolam, butor-phanol, acepromazine).

d Risk of malignant hyperthermia in certain breeds of pigs.

e Avoid xylazine as an adjunct; cardiac arrhythmia, pulmonary edema, respiratory depression may occur.

f Effective when squirted into the mouth of an intractable hissing cat, but produces copious salivation.

1.30 LIDOCAINE

Lidocaine	*Abbott Laboratories*
Lidoject	*Vetus Animal Health*
Xylocaine	*Astra Zeneca Pharmaceuticals*

1.30.1 Approved for

- Dogs, cats, horses, cattle, as an injectable anesthetic
- Not approved for antiarrhythmic properties

1.30.2 Features

- Amide local anesthetic
- Produces reversible depression of nerve conduction by blocking sodium channels
- Prevents rapid influx of sodium ions into nerve axon and production of action potential, resulting in local muscle paralysis and analgesia
- Rapid onset (2 minutes)
- Short duration of action (20 minutes to 2 hours); can be prolonged by using lidocaine containing epinephrine at 1:200,000 or 1:400,000
- Combines with myocardial sodium channels to attenuate diastolic depolarization
- Little or no effect on SA automaticity or AV node conduction
- Some enhancement of gut motility
- Metabolized by liver to active metabolites and excreted by kidneys
- Available as spray, lubricant gel, or injectable liquid

1.30.3 Uses

- Regional analgesia and muscle relaxation (e.g., limb, brachial plexus)
- Topical application to larynx of susceptible species (e.g., cats, pigs, rabbits) to reduce vocal cord spasm during intubation
- Lubrication of endotracheal tubes to reduce irritation of mucosa

- Nerve blockade (e.g., dental, paravertebral, cat paw)
- Analgesia for standing surgery (e.g., castration, epidural, paravertebral, dehorning, enucleation)

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- Correction of ventricular tachycardia and premature ventricular complexes (not approved for this use)

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- Treatment of postoperative ileus (horse)
- Analgesia of the genitourinary tract to facilitate catheterization
- Postoperative analgesia as constant-rate infusion

1.30.4 Precautions

- Do not use lidocaine that contains epinephrine for treatment of arrhythmias, for laryngeal spray, or for lubrication
- Do not use in patients with severe SA or AV heart block
- Use cautiously in patients with other bradyarrhythmias with premature ventricular contractions (PVCs)
- Do not use infiltration near inflamed, infected, or neoplastic tissue
- Use cautiously in patients with liver disease, shock, or hypovolemia
- Toxic IV dose for most species is 10 to 20 mg/kg (6 to 8 mg/kg in cattle; 10 mg/kg in goats)
- Cats are sensitive to toxic effects of local anesthetics; use cautiously with careful monitoring; seizures may be treated with diazepam
- Benzocaine-containing spray may cause methemoglobinemia in sheep
- Toxic effects of overdose produce either CNS effects (seizures, drowsiness) or cardiovascular effects (arrhythmias, cardiovascular collapse)
- Treatment after overdose is supportive

1.30.5 Doses

1.30.5.1 For Single Nerve Block with 2% Lidocaine

- 5 to 20 ml per nerve site in large animal species
- 2 to 5 ml per nerve site in medium animals (e.g., pigs, dogs)
- 0.1 to 0.2 ml per nerve site in small animals (e.g., cats, rabbits, ferrets, very small dogs)

Doses of Lidocaine by Species

Species	Infiltration of Tissues (mg/kg)	Epidural[*,†] (mg/body weight)	Intrapleural (mg/kg)	Infusion[‡] (mg/kg/min)
Horses	1	6–8 ml of 2%/450 kg	1	0.05
Cattle	1	1 ml of 2%/100 kg	NA	NA
Sheep	0.05	1 ml of 2%/50 kg	1	NRP
Goats	0.05	1 ml of 2%/50 kg	1	NRP
Pigs	1	1 ml of 2%/4.5 kg	1.5	0.05
Dogs	2	1 ml of 2%/4.5 kg	1.5	0.04–0.08
Cats	2	1 ml of 2%/5 kg	1.5	0.01–0.02
Rabbits[§]	2	NRP	NRP	NRP
Ferrets[§]	1	NRP	NRP	NRP

NRP, not reported.

* These doses are guides for caudal procedures; further information is provided in the section on Epidural Blocks in Chapter 3.

† Motor blockade and hindlimb paralysis occurs in pigs, dogs, and cats.

‡ More effective if an initial IV bolus is given (slowly over 30 seconds): horses, 1.3 mg/kg; pigs, 2 to 4 mg/kg; dogs, 1 to 2 mg/kg; cats, 0.25 to 0.5 mg/kg.

§ Can dilute to 1% for adequate effect with a more convenient volume. *NA,* Not appropriate;

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1.31 MEDETOMIDINE

Domitor*Pfizer, Inc.*

1.31.1 Approved for

- Dogs over 12 weeks of age

1.31.2 Features

- Alpha$_2$ agonist with greater potency and efficacy than other alpha$_2$ agonists
- Sedative, analgesic, muscle relaxant
- Decreases requirement for other anesthetic agents
- Initial and transient vasoconstriction and hypertension (peripheral effect), then vasodilation and hypotension (central effect)
- Decreased heart rate and cardiac output
- Second-degree AV block may occur
- Increased risk of arrhythmias with catecholamines (excitement, stress) and with inhalation agents
- Decreased respiration

- Increased blood glucose
- Increased urine volume with low specific gravity
- Usually causes vomiting in dogs and cats and decreases gut secretions
- Interferes with temperature regulation
- Reverse with atipamezole

1.31.3 Uses

- Sedation and restraint for physical examinations and simple procedures such as radiologic and minor dental procedures; not suitable for surgery
- Often used in combination with other drugs for more balanced anesthesia

1.31.4 Precautions

- Excited dogs may not respond well
- Rapid IV administration in small animal species can cause severe bradycardia, cardiac arrhythmias, and hypoxemia
- Propofol after medetomidine may cause hypoxemia

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- Do not use in animals in shock or with cardiac dysfunction
- Do not use in animals with respiratory, renal, or hepatic disease
- Do not use in stressed or debilitated animals
- Do not use in pregnant animals
- Do not use in animals with an obstructed urethra or ruptured bladder
- Do not use in animals with gut obstruction
- Do not use in patients with diabetes
- Aggression may occur in dogs after rapid reversal

1.31.5 Doses

Doses of Medetomidine by Species

Species	IV Bolus (mg/kg)	IM, SC* (mg/kg)
Horses†	0.01	0.03
Cattle	0.02	0.05
Sheep	NRP	NRP
Goats	NRP	NRP
Pigs‡	0.02–0.04	0.08
Dogs§	0.01	0.04
Cats	0.04	0.08
Rabbits	NA	0.25
Ferrets	NA	0.1

NA, Not appropriate; *NRP*, not reported.

* IM route is preferred because of unreliable absorption with SC route.

† More ataxia and disorientation than with xylazine or detomidine; brady-cardia and sedation only transiently influenced by atipamezole reversal.

‡ More effective for sedation than xylazine in this species.

§ Dosage chart is provided with product.

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1.32 MEPERIDINE

Demerol *Sanofi-Synthelabo, Inc.*
Meperidine *Abbott Laboratories*

1.32.1 Approved for

- No veterinary species

1.32.2 Features

- DEA Schedule II controlled substance
- Agonist at mu opiate receptor
- Long onset (30 to 45 minutes)
- Short duration in dogs and cats (1 to 2 hours); longer in other species (1 to 4 hours)
- Vagolytic and negative inotropic effects
- Respiratory depression comparable to that of morphine
- Usually no vomiting
- Mydriasis in dogs

- May cause histamine release when used IV
- Metabolized in liver by hydrolysis and some conjugation (metabolism is not slower in cats)
- Reverse with naloxone

1.32.3 Uses

- Premedication before surgery
- Relief of mild-to-moderate pain (e.g., with pancreatitis)

1.32.4 Precautions

- Use cautiously in patients with head trauma or increased intracranial pressure
- Do not use in patients with respiratory disease or obstruction
- Use cautiously in patients with colic as it may mask progression of the disease
- Do not use in patients with severe renal disease or hypothyroidism
- Use very cautiously IV because of possible histamine release and hypotension
- May cause CNS excitement in horses

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1.32.5 Doses

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Doses of Meperidine by Species

Species	IV (mg/kg)	IM, SC (mg/kg)
Horses*	0.2–0.4	1–4
Cattle	NA	3.3–4.4
Sheep	NA	NA
Goats	NA	NA
Pigs†	NA	1–2
Dogs	NA	3–5
Cats	NA	3–5
Rabbits	NRP	10–20
Ferrets	NA	5–10

NA, Not appropriate; *NRP*, not reported.

* May cause excitement; best used with another agent such as acepro-mazine or xylazine.

† Not effective for sedation when used alone; best used with other agents.

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1.33 MEPIVACAINE

Carbocaine *Pfizer, Inc.*
Abbott Laboratories

1.33.1 Approved for

- Horses not intended for food

1.33.2 Features

- Amide local anesthetic
- Produces reversible depression of nerve conduction by blocking sodium channels
- Prevents rapid influx of sodium ions into nerve axon and production of action potential, resulting in local muscle paralysis and analgesia
- Moderate onset (2 to 4 minutes)
- Moderate duration of action (2 to 4 hours)
- Metabolized by liver and excreted by kidneys

1.33.3 Uses

- Regional analgesia and muscle relaxation
- Nerve blockade (e.g., dental)
- Not as commonly used as other local anesthetics in veterinary medicine; used mainly in dogs and horses

1.33.4 Precautions

- Toxic dose in dogs is 29 mg/kg IV
- Cats are most sensitive to toxic effects of local anesthetics
- Toxic effects of overdose produce either CNS effects (seizures) or cardiovascular effects (arrhythmias or cardiovascular collapse)
- Treatment after overdose is supportive

1.33.5 Doses

- For dental blocks: 1 to 2 ml total dose for all blocks performed at same time
- For single nerve blocks elsewhere in body: 0.5 to 2 ml per nerve site, depending on size of animal; always monitor for signs of toxicity

Doses of Mepivacaine by Species

Species	Infiltration (mg/kg)	Epidural (mg/kg)	Intrapleural (mg/kg)
Horses	1	1.5–2 ml of 2%/horse*	NRP
Cattle	NRP	NRP	NRP
Sheep	NRP	NRP	NRP
Goats	NRP	NRP	NRP
Pigs	NRP	NRP	NRP
Dogs	2	NRP	NRP
Cats	NRP	NRP	NRP
Rabbits	NRP	NRP	NRP
Ferrets	NRP	NRP	NRP

* Subarachnoid administration, not epidural. *NRP,* Not reported.

1.34 MIDAZOLAM

Midazolam *Baxter Healthcare Corporation*
Abbott Laboratories

1.34.1 Approved for

- No veterinary species

1.34.2 Features

- DEA Schedule IV controlled substance
- Benzodiazepine
- Acts at GABA receptor
- Anxiolytic
- Muscle relaxant
- Hypnotic
- Anticonvulsant
- Water-soluble preparation, but lipid soluble at body pH, therefore rapid onset

1.34.3 Uses

- Sedation and tranquilization
- Premedication: as addition to opiate analgesic to produce neuroleptanalgesia
- Treatment of muscle fasciculation induced by propofol or other anesthetics

- Treatment of seizures

1.34.4 Precautions

- No analgesia (not to be used for painful procedures unless administered with analgesic)
- May cause excitement when administered alone (especially cats and horses)
- Exercise care in patients with hepatic or renal disease or respiratory depression
- Exercise care with debilitated patients or those in shock

1.34.5 Doses

Doses of Midazolam by Species

Species	IV (mg/kg)	IM, SC (mg/kg)
Horses	0.01–0.03	NA
Cattle	NRP	NRP
Sheep	NRP	NRP
Goats	NRP	NRP
Pigs	0.1–0.5	0.1–0.5
Dogs	0.1–0.3	0.1–0.3
Cats	0.1–0.3	0.1–0.3
Rabbits	1–2	1–2
Ferrets	NRP	0.3–1

NA, Not appropriate; *NRP*, not reported.

1.35 MORPHINE

Morphine	*Baxter Healthcare Corporation* *Abbott Laboratories*

1.35.1 Approved for

- No veterinary species

1.35.2 Features

- DEA Schedule II controlled substance
- Agonist at mu opiate receptor
- Moderate onset (20 to 30 minutes)
- Moderate duration (2 to 6 hours)
- CNS effects variable

    - Excitement in cats, horses, ruminants
    - Depression in dogs
- Respiratory depression but initially causes panting in dogs
- Bronchoconstriction in dogs
- Coronary vasoconstriction in dogs
- Causes histamine release when used IV
- Vomiting usually occurs in dogs and cats
- Depresses gut motility and increases sphincter tone but causes initial defecation in dogs
- Urine retention
- Interferes with temperature regulation
    - Hyperthermia may occur in horses, cattle, goats, and cats
    - Hypothermia may occur in dogs and rabbits
- Miosis in dogs and rabbits
- Metabolized in liver, mainly by glucuronidation (slower metabolism in cats)
- Reverse with naloxone

1.35.3 Uses

- Premedication before surgery
- Relief of moderate-to-severe pain
- Addition to sedative or tranquilizer to produce neuroleptanalgesia (e.g., for prolonged standing procedures in horses)

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- Not suitable for epidural analgesia unless product is preservative free (see discussion of Duramorph earlier in chapter)

1.35.4 Precautions

- Do not use in patients with head trauma or increased intracranial pressure
- Do not use in patients with respiratory depression
- Do not use in patients with gut obstruction

- Use cautiously in patients with severe renal insufficiency (because of increased antidiuretic hormone [ADH] release by morphine) or hepatic disease
- Use cautiously in patients with hypothyroidism
- Do not use in debilitated patients

1.35.5 Doses

Doses of Morphine by Species

Species	IV (mg/kg)	IM, SC (mg/kg)
Horses*	0.02–0.04	0.22
Cattle*	NA	NA
Sheep*	NA	NA
Goats*	NA	NA
Pigs*	NA	0.2
Dogs	1–2	1–2
Cats*	0.1–0.2	0.1–0.2
Rabbits	NA	2.5
Ferrets†	NA	NA

NA, Not appropriate.

* Causes excitement in these species; use after adequate tranquilization.

† Reliably causes vomiting in this species; used in research models of antiemetics but not used in veterinary anesthesia.

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1.36 NALOXONE

Naloxone *Abbott Laboratories*

1.36.1 Approved for

- No veterinary species

1.36.2 Features

- Opiate antagonist that acts primarily at mu receptor and also at kappa and sigma receptors
- Structurally similar to oxymorphone
- Antagonizes pure agonists, partial agonists, agonists-antagonists
- No analgesic activity
- Rapid onset within 1 to 2 minutes IV, 5 minutes IM
- Relatively short duration (approximately 45 minutes)

- All effects are reversed, including analgesia
- Metabolized in liver by glucuronidation

1.36.3 Uses

- Reverse effects of opiates after anesthesia (e.g., to shorten recovery)
- Resuscitation of newborns after cesarean section

1.36.4 Precautions

- Rapid administration may cause excitement
- Additional doses may be necessary, especially after use of opiates with relatively prolonged duration (e.g., buprenorphine)
- Analgesia is reversed, so other analgesic agents may be necessary
- Use with caution in patients with cardiac disease

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1.36.5 Doses

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Doses of Naloxone by Species

Species	IV (mg/kg)	IM (mg/kg)
Horses	0.01–0.02	NA
Cattle	*	*
Sheep	*	*
Goats	*	*
Pigs	*	*
Dogs	0.002–0.02	0.002–0.02
Cats	0.05–0.1	0.05–0.1
Rabbits	0.005–0.1	0.005–0.1
Ferrets	*	*

NA, Not appropriate.

* Although not reported specifically for these species, a dose of 0.01 mg/kg is probably most appropriate.

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1.37 NEOSTIGMINE

Neostigmine	*Baxter Healthcare Corporation* *Valeant Pharmaceuticals International* *Abbott Laboratories*

1.37.1 Approved for

- No veterinary species

1.37.2 Features

- Parasympathomimetic agent
- Competes with ACh for acetylcholinesterase, allowing ACh to accumulate and have prolonged effect
- Requires several minutes for full effect (slower than edrophonium)
- Increases tone of skeletal muscle
- Increases bladder tone
- Increases salivation
- Causes miosis
- Causes bradycardia
- Causes bronchoconstriction
- Constricts ureter
- Metabolized in liver and also hydrolyzed by plasma cholinesterases

1.37.3 Uses

- Reversal of neuromuscular blockade by nondepolarizing agents
- Diagnosis of myasthenia gravis
- Initiation of peristalsis and promotion of micturition

1.37.4 Precautions

- For reversal of neuromuscular blockade, use only several minutes after an anticholinergic has been administered to block muscarinic effects; failure to wait sufficiently may cause severe bradycardia (muscarinic effects more pronounced than with edrophonium)

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- To assess adequacy of muscle function
  - Use peripheral nerve stimulator
  - Assess inspiratory effort when occluding endotracheal tube
  - Measure tidal volume with a volumeter
- Exercise caution in patients with bronchial asthma or cardiac dysrhythmias
- Elimination is prolonged in patients with renal failure

- Exercise caution when administering to patients with symptoms of myasthenic weakness that are also receiving anticholinesterase drugs
- Patients on steroid therapy may require higher doses of neostigmine for effect

1.37.5 Doses

- These doses are for reversal of neuromuscular blockade by nondepolarizing relaxants
- The lower end of the dose range is usually sufficient
- Occasionally a second dose may be necessary; use one half the original dose and assess effect before giving more

Doses of Neostigmine by Species

Species	IV (mg/kg)
Horses	0.022–0.044
Cattle	*
Sheep	*
Goats	*
Pigs	*
Dogs	0.02–0.06
Cats	*
Rabbits	*
Ferrets	*

* Although not reported specifically for these species, a dose of 0.02 mg/kg is probably appropriate.

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1.38 OXYMORPHONE

Numorphan *Endo Pharmaceuticals, Inc.*

1.38.1 Approved for

- No veterinary species

1.38.2 Features

- DEA Schedule II controlled substance
- Pure opiate agonist acting primarily on mu receptors
- Analgesia
- Sedation in dogs, but often euphoria in cats
- Bradycardia and increased vagal tone (central effect)
- Respiratory depression

- Panting may occur in dogs initially
- Decreased gut motility
- Vomiting in dogs less likely than with morphine
- Urine retention
- Hypothermia
- No histamine release
- Metabolized in liver, mainly by glucuronidation (slower metabolism in cats)

1.38.3 Uses

- Premedication of dogs and cats
- Analgesic for IV use during general anesthesia for painful surgical procedures
- Postoperative analgesia in dogs and cats
- Expense usually precludes its use in horses

1.38.4 Precautions

- Do not use in patients hypersensitive to opiates
- Do not use in patients with head trauma or increased intracranial pressure
- Do not use in patients with respiratory depression
- Use very cautiously in patients with gut obstruction (e.g., foreign body, GDV)
- Use cautiously in patients with bradyarrhythmias
- Use cautiously in patients with renal or hepatic disease or adrenal insufficiency

- Metabolism may be slower in cats because of lack of glucuronidase enzyme
- Cats may require a concomitant tranquilizer to avoid euphoric behavioral effects
- Reverse with naloxone

1.38.5 Doses

Doses of Oxymorphone by Species

Species	IV (mg/kg)	IM, SC (mg/kg)
Horses*	0.01–0.02	0.022
Cattle	NA	NA
Sheep	NA	NA
Goats	NA	NA
Pigs†	0.075	0.02
Dogs	0.1–0.2	0.1–0.2
Cats	0.05–0.1	0.05–0.1
Rabbits	NRP	0.05–0.2
Ferrets	0.05–0.2	0.05–0.2

NA, Not appropriate; *NRP,* not reported.

* Not appropriate in this species because of cost considerations.

† Do not use alone; best used with another agent such as xylazine or ketamine.

1.39 PHENYLEPHRINE

Phenylephrine	*Baxter Healthcare Corporation* *Butler Company* *Abbott Laboratories*

1.39.1 Approved for

- No veterinary species

1.39.2 Features

- Primarily an alpha agonist
- Causes vasoconstriction and increases blood pressure
- Causes small decrease in cardiac output
- Reflex bradycardia may occur
- Increases coronary perfusion but decreases perfusion of most other vascular beds (e.g., renal, splanchnic, pulmonary, taneous, uterine)

1.39.3 Uses

- Treatment of profound hypotension caused by overdose with acepromazine or other alpha antagonist (e.g., prazosin)
- Reduction of nasal congestion after prolonged dorsal recumbency (e.g., in horses, llamas)

- Possible reduction of bleeding after nasal biopsy (small animals) if used a few minutes before biopsy is performed

1.39.4 Precautions

- Do not use as a general aid for hypotension during anesthesia
- Always use an infusion pump for administration in small animals
- Monitor ECG and blood pressure carefully during infusion
- Patients with renal disease may be further compromised by renal vasoconstriction

1.39.5 Doses

1.39.5.1 For Nasal Congestion

- Add 1 ml of phenylephrine to 9 ml of saline and spray half this volume into each nasal passage (horse)
- Adjust volume of dilute phenylephrine to suit size of patient (e.g., 1 to 3 ml for dogs, etc.)

1.39.5.2 For IV Infusion

For phenylephrine at 10 mg/ml:

- Add 1.08 ml to 60 ml of 0.9% saline or other IV solution
- Use an infusion pump
- Start at the lowest dose and adjust as necessary
- Effects are seen within 1 or 2 minutes

Infusion rates for phenylephrine based on this dilution

$$\begin{aligned} 3\,\mu g/kg/min &= 1\,ml/kg/hr \\ 6\,\mu g/kg/min &= 2\,ml/kg/hr \\ 9\,\mu g/kg/min &= 3\,ml/kg/hr \end{aligned}$$

1.39.5.3 How the Dilution Was Calculated

For convenience, use pump settings of ml/kg/hr instead of µg/kg/min. Dilute the drug so that the lowest dose rate (3 µg/kg/min) = 1 ml/kg/hr. Phenylephrine is supplied at 10 mg/ml. The lowest dose of 3 µg/kg/min = (3 × 60) µg/kg/hr = 180 µg/kg/hr. Make this dose equal to 1 ml/kg/hr. Therefore the drug must be diluted so that 1 ml contains 180 µg (= 0.18 mg).

$$10\,mg/ml \div 0.18\,mg/ml = 55.5$$

Therefore the provided drug must be diluted by 55.5.

To end up with a 60-ml volume in the infusion syringe:

$$60\,ml \div 55.5 = 1.08\,ml$$

Therefore add 1.08 ml of phenylephrine to 60 ml of saline.

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1.39.5.4 If an Infusion Pump Is Not Available

- Use a 500-ml bag of D5W or 0.9% saline for diluent
- Use a pediatric drip set (60 drops/ml)
- Flow rate of 1 drop/sec = 1 ml/min
- Number of milliliters of phenylephrine (10 mg/ml) to add to 500 ml of fluids = body weight (kg) × 0.45

Flow rates for phenylephrine based on this dilution

$$3\,\mu g/kg/min = 1\ drop/3\,sec$$
$$6\,\mu g/kg/min = 2\ drops/3\,sec$$
$$9\,\mu g/kg/min = 1\ drop/sec$$

1.39.5.5 How the Dilution and Flow Rate Were Calculated

For convenience in setting the flow rate, make the highest administration rate of 9 µg/kg/min equal to 1 drop/sec. With a pediatric drip set at 60 drops/ml, 1 drop/sec delivers 1 ml/min. Make this equal to 9 µg/kg/min—that is, 1 ml provides 9 µg/kg. A 500-ml bag provides a total of 4500 µg/kg = 4.5 mg/kg.

Calculate how much phenylephrine to add to 500 ml as follows.

$$\text{Phenylephrine} = 10\,mg/ml$$
$$4.5\,mg/kg \div 10\,mg/ml = 0.45\,ml/kg$$

Therefore, for each kilogram of the animal's body weight, the number of milliliters of phenylephrine to add to 500 ml = 0.45.

Adjust flow rate as required, according to the flow rates previously itemized.

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1.40 PROPOFOL

PropoFlo	*Abbott Laboratories*
Propofol	*Baxter Healthcare Corporation*
Rapinovet	*Schering-Plough Corporation*

1.40.1 Approved for

- Dogs, cats

1.40.2 Features

- Produces rapid and excitement-free induction and recovery
- No analgesia
- Nonirritant to tissues if extravascular injection occurs
- Apnea occurs with rapid injection
- Causes hypotension, especially with rapid injection
- Myoclonus may occur in some animals
- Product contains no preservative and formulation supports bacterial growth

1.40.3 Uses

- Induction of anesthesia before maintenance with inhalant agents
- Induction and maintenance of anesthesia for short procedures by intermittent boluses
- Maintenance of anesthesia for more prolonged procedures (e.g., diagnostic imaging, surgery) by constant-rate infusion

1.40.4 Precautions

- Repeated doses in cats may cause formation of Heinz bodies
- Prolonged infusions in cats (e.g., > 2 hours) may cause delayed recovery (slow metabolism)
- Formulation supports bacterial growth; discard opened vials after 6 hours or at end of anesthesia, whichever occurs sooner

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1.40.5 Doses

Doses of Propofol by Species

Species	IV Bolus (mg/kg)	IV Infusion (mg/kg/min)
Horses*	NA	NA
Cattle*	NA	NA
Sheep*	4–6	NRP
Goats*	4–6	NRP
Pigs*	4–6	0.07–0.13
Dogs†	4–6	0.2–0.4
Cats	4–6	0.2–0.4
Rabbits‡	4–8	NRP
Ferrets	NRP	NRP

NA, Not appropriate; *NRP*, not reported.

* Not appropriate for these species because of cost and large volume required.

† May be cost prohibitive in large dogs.

‡ Inject cautiously to reduce likelihood of apnea.

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1.41 SEVOFLURANE

SevoFlo *Abbott Laboratories*

1.41.1 Approved for

- Dogs, horses not intended for food

1.41.2 Features

- Potent inhalant agent for general anesthesia
- Precision vaporizer required
- Rapid induction and recovery (faster than with isoflurane or halothane)
- No analgesia
- Myocardial depression and vasodilation
- Sensitizes myocardium to catecholamine-induced arrhythmias
- Not irritating to airway but causes respiratory depression
- Increases cerebral blood flow and intracranial pressure
- Depression of temperature regulation

- May trigger malignant hyperthermia in susceptible species or breeds

1.41.3 Uses

- Induction of anesthesia in chamber or by mask (e.g., in cats, exotics, neonates)
- Induction via nasotracheal tube in neonatal foals
- Maintenance of general anesthesia in all species

1.41.4 Precautions

- Do not use in patients with head trauma or possible brain tumor
- Do not use in patients susceptible to malignant hyperthermia
- Monitor patients closely, and adjust setting as required
- Avoid exposing pregnant staff to vapor

1.41.5 Doses

- For anesthetic maintenance, aim for end-tidal concentration of 1.5 × MAC
- Various factors affect MAC, and these must be taken into account when determining the optimum setting to use (see discussions of Sevoflurane and MAC in Appendix A)

MAC Values for Sevoflurane by Species

Species	MAC Value	1.5 × MAC
Horses	2.31	3.5
Cattle	NRP	NRP
Sheep	3.3	4.95
Goats	2.33	3.5
Pigs	2.66	4
Dogs	2.36	3.5
Cats	2.58	3.9
Rabbits	3.7	5.6
Ferrets	2.7	4.1

NRP, Not reported.

1.42 TELAZOL (TILETAMINE-ZOLAZEPAM)

Telazol *Fort Dodge Laboratories*

1.42.1 Approved for

- Cats, dogs

1.42.2 Features

- DEA Schedule III controlled substance
- Rapid induction of dissociative anesthesia
- Low pH (2.2 to 2.8) causes pain on injection
- Analgesia and muscle relaxation
- Salivation, bradycardia, hypotension in cats
- Salivation, tachycardia in dogs
- No abolition of reflexes (e.g., palpebral, pedal, laryngeal)
- Pupillary dilation
- Respiratory depression
- Hypothermia
- Prolonged recovery, which may be erratic with vocalization and muscle twitching
- Zolazepam component lasts longer in cats (tranquilization lasts longer than anesthesia in recovery)
- Tiletamine component lasts longer in dogs (anesthesia lasts longer than tranquilization in recovery)
- Reported to be toxic to rabbit kidneys at high doses

1.42.3 Uses

- Restraint for diagnostic procedures
- Anesthesia for minor surgical procedures
- Restraint and sedation of various exotic species

1.42.4 Precautions

- Cover eyes to protect from corneal desiccation and excess light to retina
- Not suitable for use during major surgery
- Do not use in patients with cardiac or respiratory disease
- Do not use in patients with renal disease
- Do not use for cesarian section or in pregnant patients

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- Do not use in rabbits with dehydration or renal disease
- Anticholinergics may be required to control salivation
- Monitor temperature and respiratory function carefully during recovery
- Emesis may occur during recovery

1.42.5 Doses

- Use lower doses for diagnostics and higher doses for minor surgical procedures

Doses of Telazol by Species

Species	IV (mg/kg)	IM (mg/kg)
Horses*	1.6–2.2	NRP
Cattle†	NA	NA
Sheep†	NA	NA
Goats†	NA	NA
Pigs‡	NA	NA
Dogs	NA	6.6–13
Cats	NA	10–12
Rabbits§	NA	5–25
Ferrets	NA	22

NA, Not appropriate; *NRP*, not reported.

* Use only after xylazine premedication at 1.1 mg/kg IV.

† Not suitable for ruminants because of prolonged recovery.

‡ Not suitable alone for pigs but is ideal when added to xylazine and ketamine; see Chapter 2.

§ Nephrotoxicy occurs at doses of 3 to 64 mg/kg.

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1.43 THIOPENTAL

Pentothal *Abbott Laboratories*

1.43.1 Approved for

- No veterinary species (although not approved, it is labeled for veterinary use)

1.43.2 Features

- DEA Schedule III controlled substance
- Rapidly acting general anesthetic for IV use only
- No analgesic properties

- Apnea with rapid injection
- Respiratory depression and hypotension common initially
- Transient ventricular bigeminy common in dogs
- Decreased leukocyte count and hematocrit in dogs
- Rapid redistribution accounts for short anesthetic action
- More rapidly eliminated by sheep than by other species
- More slowly eliminated by sighthounds than by other species
- Without sufficient premedication, recovery can be rough, with risk of injury
- Highly alkaline solution; irritant to tissues if injected extravascularly

1.43.3 Uses

- Rapid induction of general anesthesia
- Not suitable for maintenance except for very short periods (e.g., approximately 10 to 15 minutes)

1.43.4 Precautions

- More potent action in acidemia because of greater proportion of unionized molecules and easier entry into cells
- Do not use for patients in shock
- Do not use for patients with severe cardiac disease or asthma

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- Use cautiously for patients with increased intracranial pressure
- Use cautiously or not at all in sighthounds
- Do not use with epinephrine (increased risk of ventricular fibrillation)
- Administration of glucose during recovery may reanesthetize dogs and rabbits because of depression of hepatic enzymatic activity by glucose
- Always use a catheter
- For accidental extravascular injection, flood the area with saline to dilute the drug
- Lidocaine may also be useful for local analgesia
- Warm compresses can be used to reduce inflammation

- Accidental intracarotid injection in horses causes seizures; treat immediately with diazepam

1.43.5 Doses

- Always administer *to effect,* and carefully monitor respiratory and cardiovascular systems
- Often mixed with guaifenesin for administration to horses and farm animals or administered as a bolus after guaifenesin has produced sufficient relaxation
- For small animal species, depending on degree of sedation, one half to two thirds of IV bolus can be injected initially to assess effect before the remainder is administered

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Doses of Thiopental by Species

Species	IV Bolus after Sedation (mg/kg)	IV with (or Bolus after) Guaifenesin, after Sedation (mg/kg)	Approximate Supplemental Doses, if Required (mg/kg)
Horses	8–10	3–4	3–4
Cattle*	10–15	4–8	3–4
Sheep*	10–15	4–8	3–4
Goats*	10–15	4–8	3–4
Pigs*	15–30	NA	3–4
Dogs†	10–15	NA	3–4
Cats	10–15	NA	3–4
Rabbits	15–20	NA	3–4
Ferrets	NRP	NA	NA

NA, Not appropriate; *NRP,* not reported.

* Farm animals may not always be administered sedatives before general anesthesia; use lower end of range if sedatives are used.

† See notes under Features and Precautions regarding sighthounds.

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1.44 XYLAZINE

Sedazine	*Fort Dodge Laboratories*
Xylazine	*Butler Company*
X-ject E	*Vetus Animal Health*
X-ject SA	*Vetus Animal Health*

1.44.1 Approved for

- Dogs, cats, horses, deer, elk

1.44.2 Features

- Alpha$_2$ agonist with some alpha$_1$ activity
- Sedative, analgesic, muscle relaxant

- Decreases MAC and the requirement for other anesthetic agents
- Ruminants are extremely sensitive; pigs are least sensitive
- Initial and transient vasoconstriction and hypertension (peripheral effect), then vasodilation and hypotension (central effect)
- Decreased heart rate, cardiac output
- Second-degree AV block commonly seen
- Increased risk of arrhythmias with catecholamines (excitement, stress) and with inhalation agents
- May cause pulmonary edema in certain breeds of sheep (Swedish Landrace)
- Decreased erythrocyte count, hemoglobin concentration, packed cell volume in cattle
- Increased blood glucose and decreased insulin within approximately 30 minutes, lasting several hours; peak glucose value may be 1½ to 3 times normal, and peak occurs at approximately 2 hours in dogs and cats, 30 to 45 minutes in horses, and 3 hours in cattle
- Increased urine volume and decreased osmolality and specific gravity
- Usually causes vomiting in dogs and cats
- Causes splenic contraction in dogs
- Dilates stomach and intestines of dogs at doses of 2 to 3 mg/kg IV
- Causes pronounced salivation in ruminants

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- Interferes with temperature regulation
- Reverse with yohimbine or atipamezole

1.44.3 Uses

- Analgesic for visceral pain in horses (colic)
- Sedation of horses and farm animals
- Sedation of healthy and feral dogs and cats
- Postoperative analgesia at very low doses in small animal species

1.44.4 Precautions

- Rapid IV administration in small animal species can cause severe bradycardia, cardiac arrhythmias, hypoxemia

- Do not use in animals in shock or with cardiac dysfunction
- Do not use in animals with an obstructed urethra or ruptured bladder
- Do not use in small animals with gut obstruction
- Do not use for abdominal radiographs in dogs
- Do not use in patients with diabetes
- Recover animals in a safe environment without extremes of temperature
- Clinical pathologic values may be misinterpreted after xylazine administration
- Aggression may occur in dogs after rapid reversal
- Horses may respond suddenly to external stimuli even though apparently sedated

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1.44.5 Doses

Doses of Xylazine by Species

Species	IV (mg/kg)	IM, SC (mg/kg)
Horses	0.4–1.1	1–2
Cattle*	0.03–0.1	0.1–0.2
Sheep*	0.025–0.1	0.1–0.3
Goats*	0.05–0.1	0.1–0.3
Pigs†	1–2	2–4
Dogs‡	0.25–0.5	0.5–2
Cats‡	0.25–0.5	0.5–1
Rabbits§	1	3–5
Ferrets	NA	1–2

NA, Not appropriate.

* These species are not always premedicated before general anesthesia. These doses are for tranquilization (e.g., for radiology, wound examination).

† Not effective alone for pigs. Best used in conjunction with another drug (e.g., ketamine or an opioid).

‡ Not favored for premedication of these species because of cardiac and other effects, except for young healthy animals or to capture feral animals. Can be used for postoperative analgesia at 2 to 3 μ/kg IM or IV, usually with other analgesics.

§ Rabbits are prone to respiratory depression and hypotension. Use cautiously until effective. Best used with another drug (e.g., ketamine).

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1.45 YOHIMBINE

Yobine	*Lloyd Laboratories*
Antagonil	*Wildlife Pharmaceuticals, Inc.*

1.45.1 Approved for

- Dogs (Yobine)
- Deer (Antagonil)

1.45.2 Features

- An alpha$_2$ antagonist
- Effects occur within a few minutes when injected IV
- All effects of alpha$_2$ agonist are reversed, including analgesia

1.45.3 Uses

- Reversal of the effect of xylazine
- Especially useful in exotics, wildlife, food animal species
- Usually administered IV, but SC or IM may be used for slower reversal
- Use the same dose for all routes

1.45.4 Precautions

- CNS excitement and muscle tremor may occur
- Rapid administration IV may cause excitement and aggression
- Use cautiously in animals with a history of seizures
- Use in a calm, quiet environment to decrease adverse effects
- Inject incrementally and slowly to decrease adverse effects

1.45.5 Doses

Doses of Yohimbine by Species

Species	IV (mg/kg)	IM, SC (mg/kg)
Horses	0.075	NRP
Cattle	0.12	NRP
Sheep	1	NRP
Goats	NRP	NRP
Pigs*	0.05	NA
Dogs	0.1	0.1
Cats	0.1	0.1
Rabbits	0.2	NRP
Ferrets	0.2	NRP

NA, Not appropriate; *NRP*, not reported.

* Because pigs are so resistant to the effects of xylazine, reversal is seldom necessary.

2 Chapter 2 Drug Combinations

2.1 HORSES

2.1.1 IV Sedation

2.1.1.1 Uses

- Examinations
- Standing procedures
- Premedication before inhalation anesthesia

Xylazine 0.5 mg/kg IV or Detomidine 0.02 mg/kg IV

For greater effect:

+ Butorphanol 0.03 mg/kg IV

Acepromazine 0.05 mg/kg IV

For greater effect:

+ Butorphanol 0.03 mg/kg IV or

Detomidine 0.01-0.02 mg/kg IV

Xylazine 0.66 mg/kg IV

Morphine 0.66 mg/kg IV very slowly

See important note below

2.1.1.2 Features

Xylazine or detomidine ± butorphanol:

- Shorter duration with xylazine than detomidine

Acepromazine ± butorphanol or detomidine:

- Acepromazine has relatively long onset, up to 10 minutes even when used IV
- Ideal for sedation of mares during anesthesia of foal (especially with detomidine)
- Drug metabolites may pass into milk

Xylazine + morphine:

- Suitable for use *only* during long procedures (approximately 3 hours; e.g., perineal laceration repair, standing abdominal procedures) 101
- *Must* wait for heavy sedation before morphine is used 102
- Inject morphine slowly, and watch carefully for signs of histamine release (cutaneous wheals)
- Sweating occurs on head and neck
- Horse has rigid sawhorse stance with head and neck leaning forward; take care that trachea is not occluded by ropes, etc.
- Duration of effect of xylazine is much shorter than that of morphine; horse becomes restless as xylazine wears off; repeated doses are required approximately every 20 to 30 minutes initially, then at longer intervals with successive doses; use as needed
- Personnel must monitor horse closely for at least 3 to 4 hours
- Morphine can be reversed with naloxone, if necessary; reverse *slowly*

2.1.2 IV Anesthesia

- Short procedures (e.g., 20 minutes)
- Can prolong to approximately 1 hour by using “triple drip”
- Can use the following combinations before inhalant anesthesia 102

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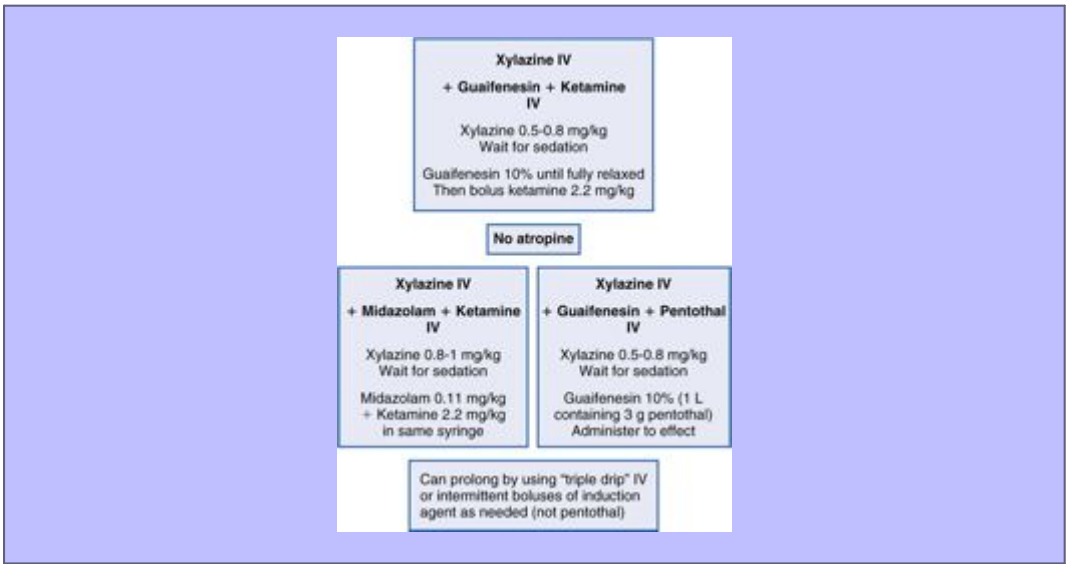

2.1.2.1 Features

- Wait for full sedation before continuing with induction
- Horses may react to sudden stimuli even if apparently fully sedated after xylazine administration
- Do not prolong by using Pentothal, because of slow and rough recovery
- Ensure good padding and eye protection, especially for procedures lasting longer than approximately 20 minutes

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2.1.3 "Triple Drip": Guaifenesin + Xylazine + Ketamine

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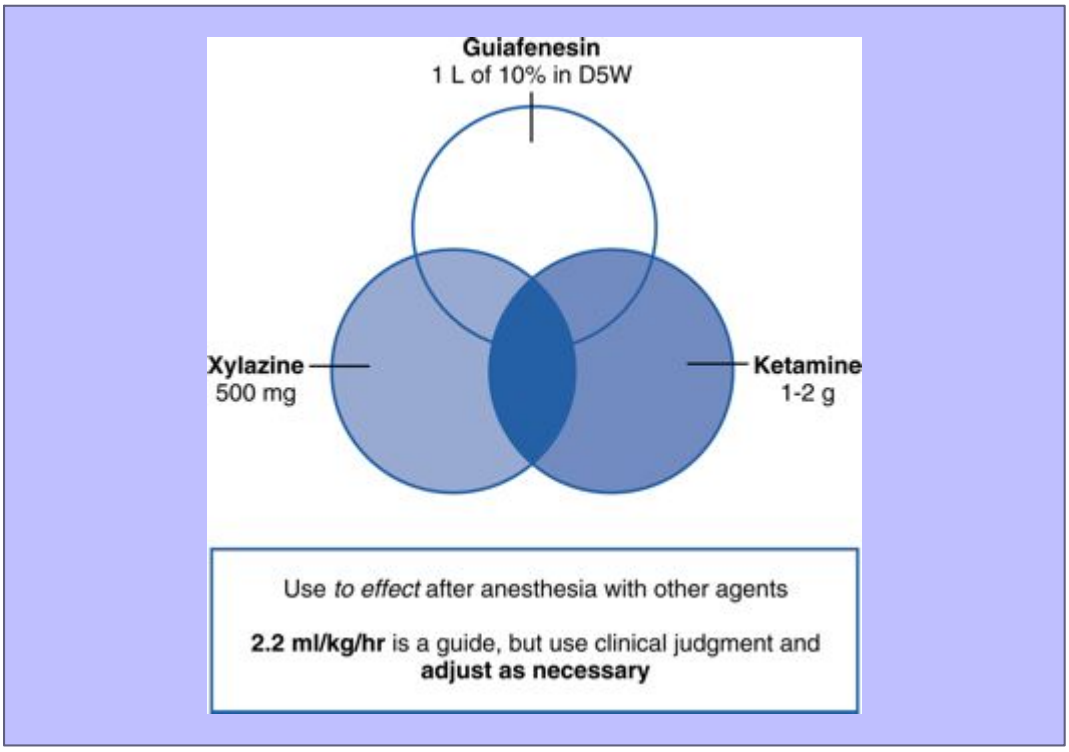

2.1.3.1 Advantages

- Usually associated with smooth recovery
- Depth of anesthesia is fairly easily manipulated; use palpebral reflex as a guide
- Causes good muscle relaxation

2.1.3.2 Disadvantages

- Respiratory depression and bradycardia occur with excess; monitor carefully
- Must record ketamine use in controlled-drug log

2.2 RUMINANTS

2.2.1 IV or IM Sedation

2.2.1.1 Uses

- Examinations
- Standing procedures with local anesthesia blocks (e.g., dehorning)

2.2.2 Cattle, Sheep, and Goats

Xylazine

0.01-0.05 mg/kg IM*

Goats are most sensitive to xylazine

Xylazine

0.02 mg/kg IM + Butorphanol

0.05-0.07 mg/kg IM

Butorphanol IV

1.1 mg/kg

* At the higher end of this range, animals may become recumbent.

2.2.3 Goats

Diazepam 0.1-0.5 mg/kg IM or IV

Midazolam 0.05-0.25 mg/kg IM or IV

Butorphanol 0.01 mg/kg IM + Acepromazine 0.05 mg/kg IM + Glycopyrrolate 0.01 mg/kg IM

2.2.3.1 Features

- Do not use detomidine in ruminants because of its prolonged action
- Do not use xylazine in goats with blocked urinary tract; increased urine volume may cause rupture of urinary bladder
- Effects of drugs depend on temperament of animal
- Acepromazine has long duration and is best avoided in ruminants

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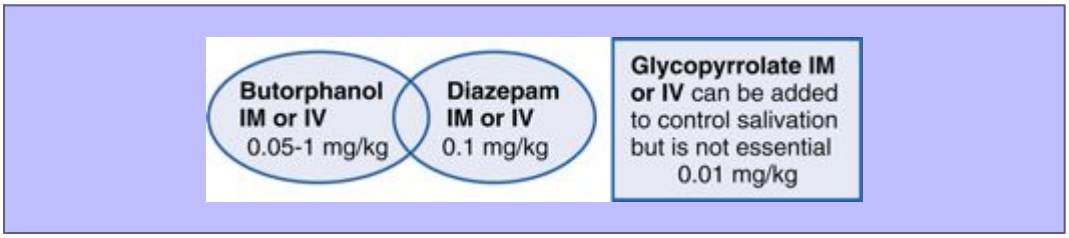
2.2.4 IM Premedication, Then IV Anesthesia

2.2.4.1 Use

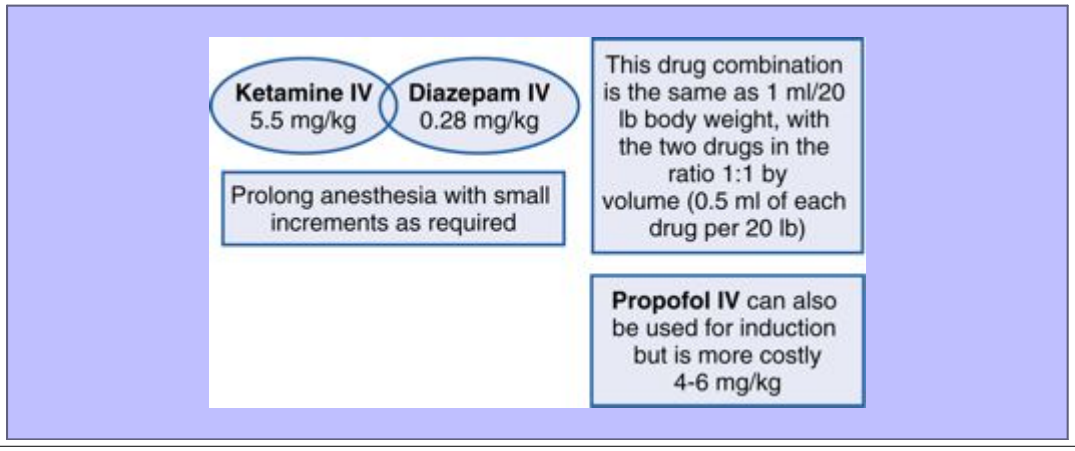
- For minor procedures (e.g., wound repair, radiographs)

2.2.5 Calves, Sheep, and Goats

2.2.6 Premedication



2.2.7 Induction



2.2.7.1 Advantages

- Associated with smooth induction and recovery
- Depth of anesthesia is fairly easily manipulated
- Causes good muscle relaxation
- Suitable for use in goats with blocked urethra

2.2.7.2 Disadvantages

- Animals must be intubated to protect airway (regurgitation is always a risk with ruminants)
- Not suitable for use during major surgery or prolonged procedures

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- Must record use of butorphanol, ketamine, and diazepam in controlled-drug log

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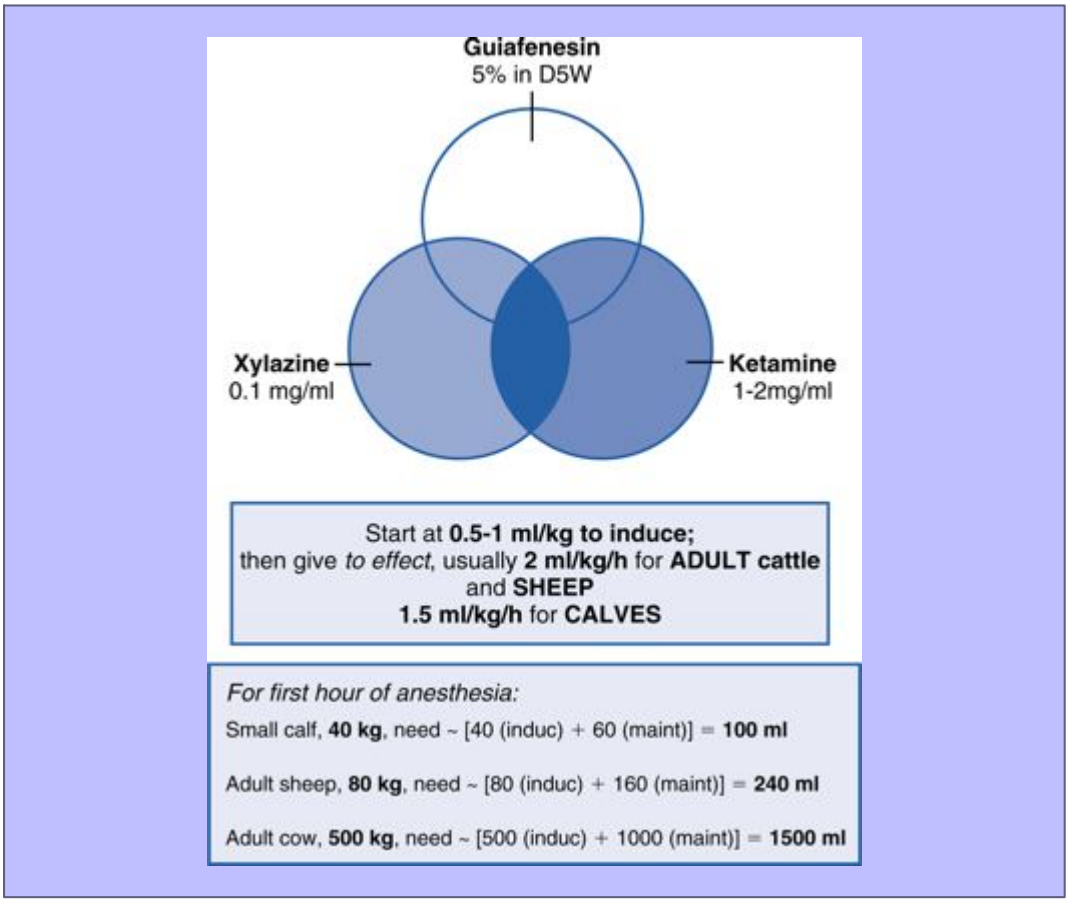
2.2.7.3 Precautions

- Ensure adequate fasting
- If possible, use padding under neck and have animal's head tilted downward so that any regurgitated material can drain from the mouth
- Move anesthetized animal as smoothly as possible
- Keep animal in sternal recumbency for recovery

2.2.8 IV Anesthesia: Guaifenesin + Xylazine + Ketamine

2.2.9 Cattle and Sheep



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2.2.9.1 Advantages

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- Associated with smooth induction and recovery
- Depth of anesthesia is fairly easily manipulated
- Causes good muscle relaxation

2.2.9.2 Disadvantages

- Must use IV route
- Must intubate animal to protect airway (regurgitation is always a risk with ruminants)
- Large volume required

- Not suitable for use during major surgery or prolonged procedures; can be used for induction before maintaining anesthesia with inhalant agents designed for such situations
- Must record use of ketamine in controlled-drug log

2.2.9.3 Precautions

- Ensure adequate fasting
- If possible, use padding under neck and have animal's head tilted downward so that any regurgitated material can drain from the mouth
- Move anesthetized animal as smoothly as possible
- Keep animal in sternal recumbency for recovery

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2.3 PIGS

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2.3.1 IM Anesthesia: Xylazine + Ketamine + Oxymorphone

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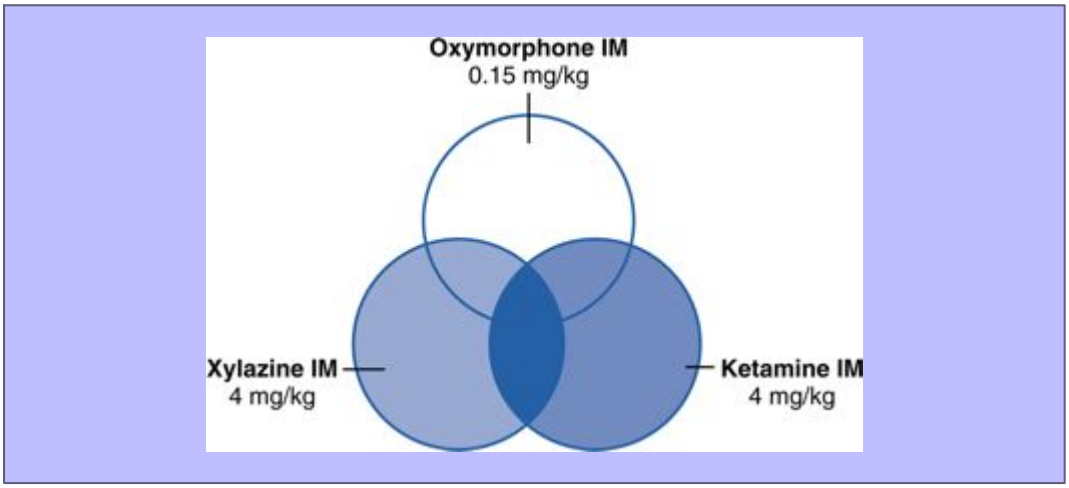


2.3.1.1 Advantages

- Easy to administer; best in muscles behind ear (thinner skin; little fat; pig cannot bite easily; minimal damage to muscle)
- Associated with smooth induction and recovery
- Causes good analgesia
- Causes good muscle relaxation (sufficient for easy intubation)
- Duration approximately 45 minutes to 1 hour

- Can hasten recovery with naloxone and yohimbine

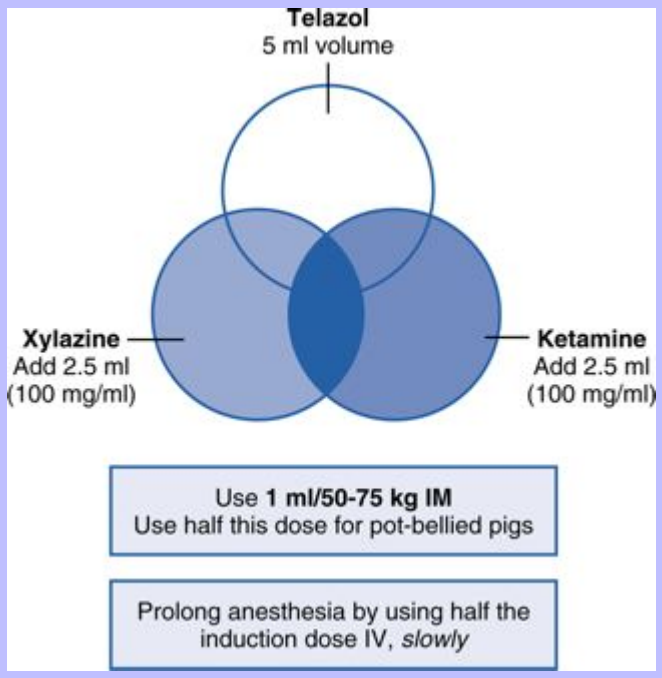
2.3.1.2 Disadvantages

- Relatively costly (oxymorphone)
- Must record use of ketamine in controlled-drug log

2.3.1.3 Precautions

- Intubate pigs to protect airway
- Fast pigs sufficiently to prevent them from vomiting
- Always monitor pigs carefully during recovery to ensure adequate respiratory function

2.3.2 IM Anesthesia: Xylazine + Ketamine + Telazol



2.3.2.1 Advantages

- Easy to administer; best in muscles behind ear (thinner skin; little fat; pig cannot bite easily; minimal damage to muscle)
- Associated with smooth induction and recovery

- Causes good analgesia
- Causes good muscle relaxation (sufficient for easy intubation)
- This combination has a reduced concentration of zolazepam as compared with telazol; less hindlimb weakness in recovery

2.3.2.2 Disadvantages

- Costly (telazol)
- Recovery may be prolonged in older animals
- Must record use of telazol and ketamine in controlled-drug log

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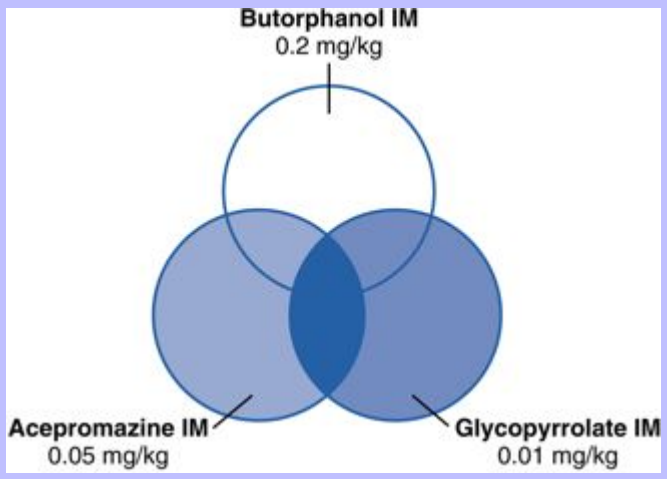
2.3.3 IM Premedication, Then IV Anesthesia

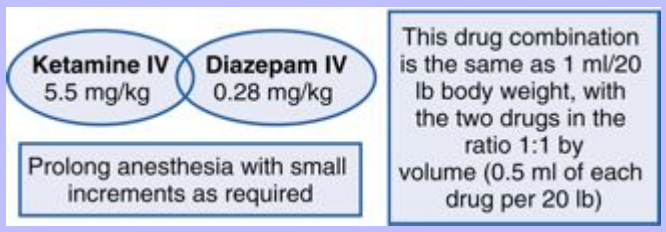
2.3.3.1 Use

- For minor procedures (e.g., trimming feet, radiographs)

2.3.4 Premedication



2.3.5 Induction



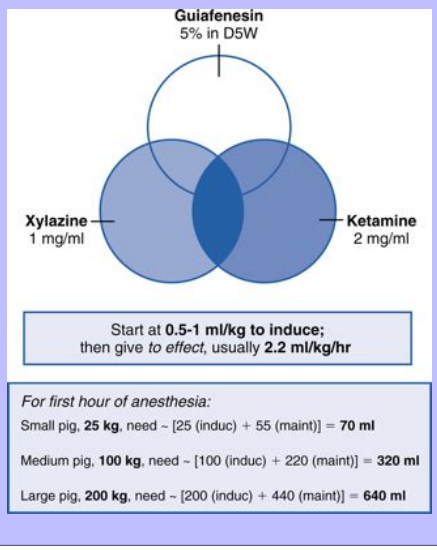
2.3.5.1 Advantages

- Associated with smooth induction and recovery
- Depth of anesthesia is fairly easily manipulated
- Causes good muscle relaxation

2.3.5.2 Disadvantages

- Premedication may not be fully effective in irascible pigs
- Intubation is advisable to protect airway
- Must record use of butorphanol, ketamine, and diazepam in controlled-drug log

2.3.6 IV Anesthesia: Guaifenesin + Xylazine + Ketamine



2.3.6.1 Advantages

- Associated with smooth induction and recovery
- Depth of anesthesia is fairly easily manipulated
- Causes good muscle relaxation
- Has minimal effect on cardiopulmonary variables
- Suitable for anesthesia up to approximately 2 hours in healthy pigs

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2.3.6.2 Disadvantages

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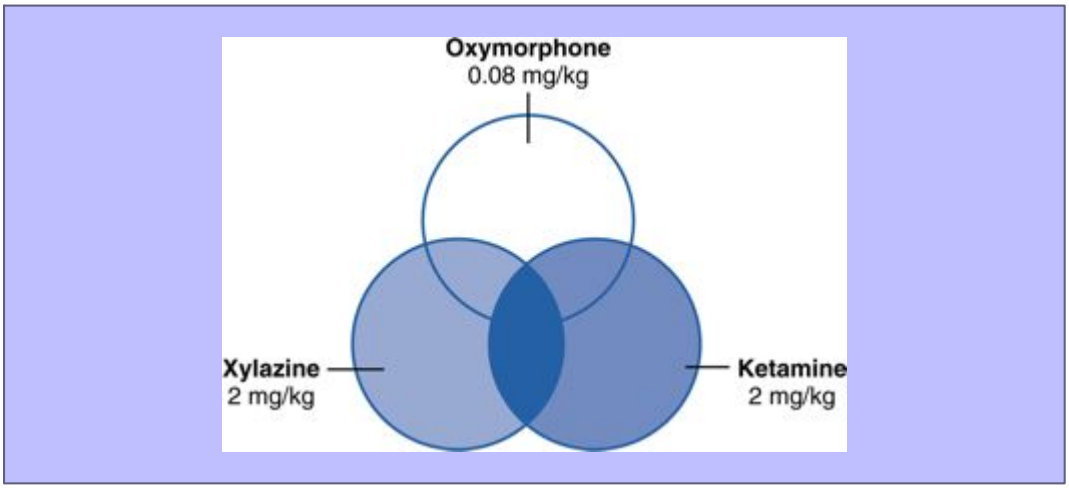
- Must use IV route
- Premedication required if pig is difficult to catheterize
- Large volume required
- Must record use of ketamine in controlled-drug log

2.3.7 IV Anesthesia: Xylazine + Ketamine + Oxymorphone



2.3.7.1 Advantages

- Associated with smooth induction and recovery
- Causes good muscle relaxation (sufficient for easy intubation)
- Causes good analgesia

- Duration approximately 30 to 45 minutes
- Recovery can be hastened with naloxone and yohimbine

2.3.7.2 Disadvantages

- Must use IV route
- Premedication required if pig is difficult to catheterize
- Relatively costly (oxymorphone)
- Must record use of oxymorphone and ketamine in controlled-drug log

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2.3.7.3 Precautions

- Intubate pigs to protect airway
- Fast pigs sufficiently to prevent them from vomiting
- Always monitor pigs carefully during recovery to ensure adequate respiratory function

2.3.8 IM or IV Anesthesia: Xylazine + Ketamine

IM anesthesia		***IV anesthesia***	
Xylazine IM	+ Ketamine IM	Xylazine IV	+ Ketamine IV
2–3 mg/kg	10–20 mg/kg	1–2 mg/kg	4–6 mg/kg
Prolong with IV doses at:		***Prolong with IV doses at:***	
Xylazine	+ Ketamine	Xylazine	+ Ketamine
0.5–1 mg/kg	2–4 mg/kg	0.5–1 mg/kg	2–4 mg/kg

2.3.8.1 Features

- IM offers easy administration; best in muscles behind ear (thinner skin; little fat; pig cannot bite easily; minimal damage to muscle)
- Associated with smooth induction
- Causes good analgesia but may respond to noxious stimuli
- Causes good muscle relaxation
- Not suitable for use during major surgery
- Recovery is generally smooth, but some excitement can occur; better with IV induction
- Must record use of ketamine in controlled-drug log

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2.3.9 IM or IV Anesthesia: Xylazine + Telazol

IM anesthesia		*IV anesthesia*	
Xylazine IM + Telazol IM		Xylazine IV + Telazol IV	
2.2 mg/kg	6.6 mg/kg	1.1 mg/kg	2.2–4.4 mg/kg

2.3.9.1 Features

- IM offers easy administration; best in muscles behind ear (thinner skin; little fat; pig cannot bite easily; minimal damage to muscle)
- Associated with smooth induction
- Causes good analgesia and muscle relaxation
- Can intubate
- IV method better for older or very large animals (shorter recovery)
- Must record use of telazol in controlled-drug log

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2.3.10 Postoperative Analgesia: Buprenorphine

Buprenorphine 0.01 mg/kg IV or IM

2.3.10.1 Features

- Drug Enforcement Administration (DEA) Schedule III controlled substance
- Partial agonist at mu opiate receptor
- Long onset (20 to 30 minutes)
- Moderate-to-long duration (6 to 8 hours)
- Minimal respiratory depression compared with pure opiate agonists
- Minimal cardiovascular depression compared with pure opiate agonists

2.3.11 Postoperative Analgesia: Butorphanol

Butorphanol 0.1-0.5 mg/kg IV or IM

2.3.11.1 Features

- DEA Schedule IV controlled substance

- Agonist-antagonist with agonist activity primarily at kappa and sigma opiate receptors
- Antagonizes pure agonists such as morphine, oxymorphone, fentanyl
- Fairly rapid onset (3 minutes IV; 20 minutes IM)
- Short-to-moderate duration (approximately 4 hours)
- Minimal respiratory depression compared with pure opiate agonists
- Minimal cardiovascular depression compared with pure opiate agonists

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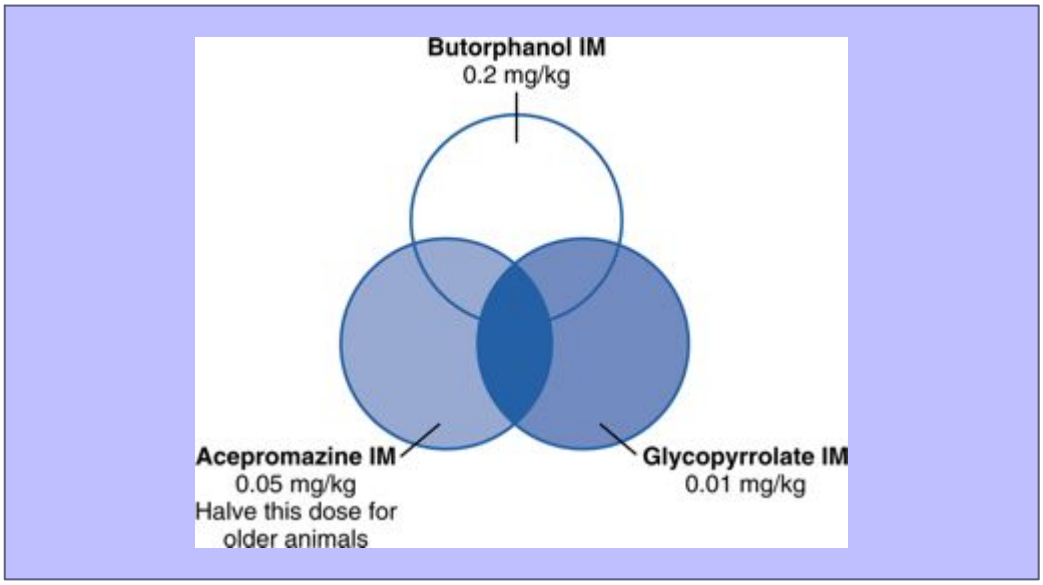
2.4 DOGS

2.4.1 IM Sedation

Halve these doses for IV use.

2.4.1.1 Uses

- Minor procedures (e.g., radiology)
- Premedication before general anesthesia



2.4.1.2 Features

- Suitable for use during basic procedures (e.g., ovariohysterectomy)
- Produces good sedation, but analgesic effect is not pronounced

- May not produce sufficient sedation in boisterous dogs
- Must record use of butorphanol in controlled-drug log

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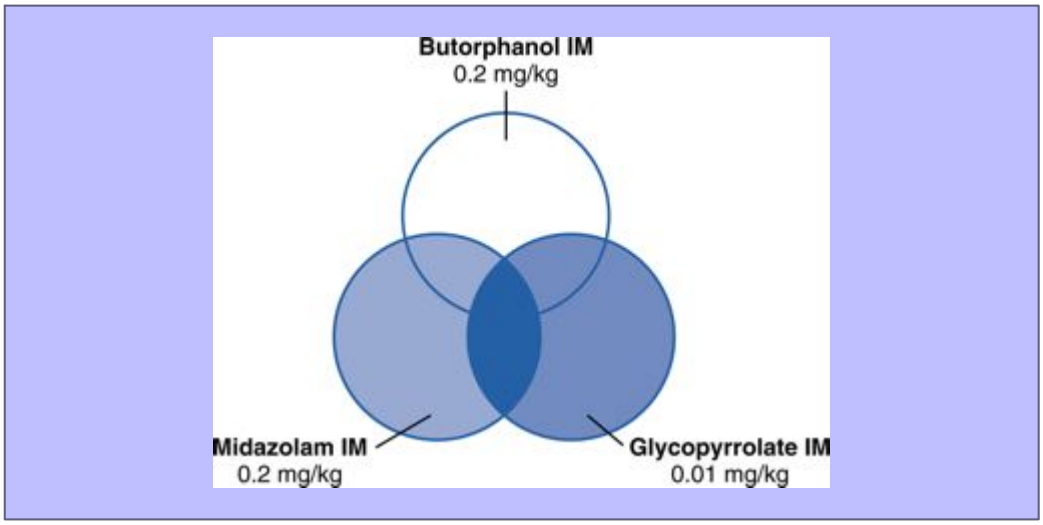
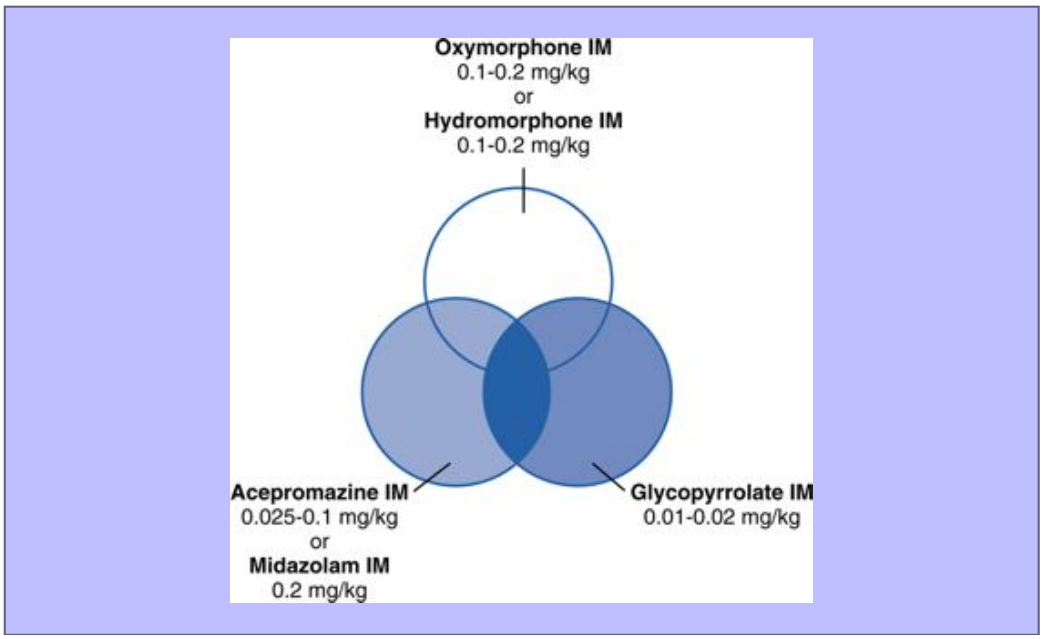


2.4.1.3 Features

- Suitable for use in dogs with increased intracranial pressure (e.g., head trauma, brain tumor)
- Produces good sedation, but analgesic effect is not pronounced
- Must record use of butorphanol and midazolam in controlled-drug log



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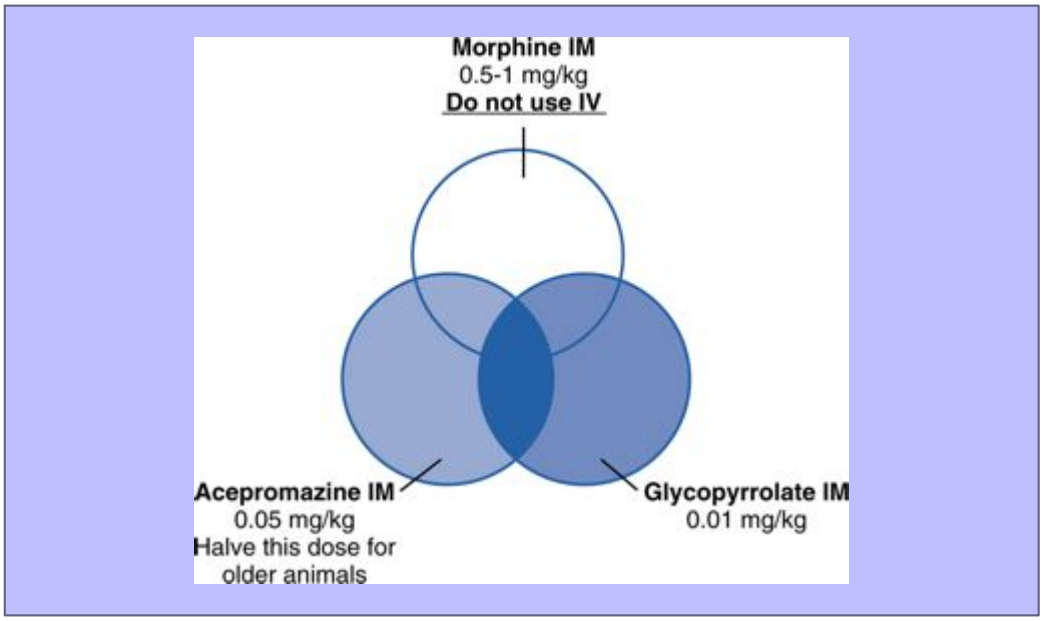
Halve these doses for IV use.

2.4.1.4 Features

- Suitable for use during more painful procedures
- Suitable for use in aggressive dogs
- Dogs may vomit
- Possibility of mild histamine release with hydromorphone IV
- Hypothermia likely; monitor temperature
- Must record use of oxymorphone, hydromorphone, and midazolam in controlled-drug log



2.4.1.5 Features

- Suitable for use during more painful procedures
- Suitable for use in aggressive dogs
- Dogs will vomit; suitable for use in dogs recently fed or with uncertain fasting history
- Do not use with gut obstruction
- Morphine IV causes histamine release
- Must record use of morphine in controlled-drug log

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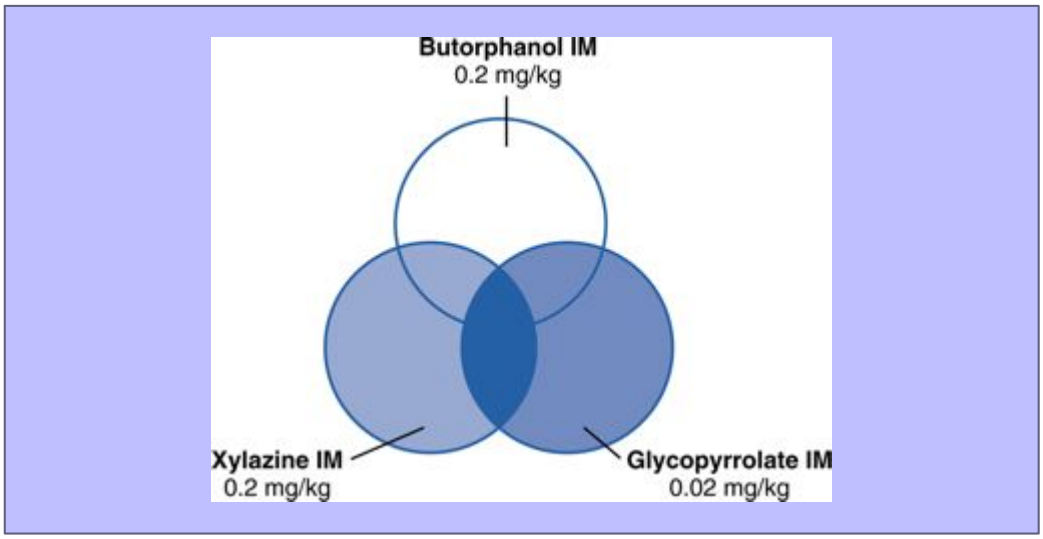

2.4.1.6 Features

- Suitable for use in anxious or “caution” dogs
- Dogs may vomit; suitable for use in dogs recently fed or with uncertain fasting history
- Do not use with gut obstruction
- Do not use in diabetic animals
- Do not use in animals with heart disease
- Must record use of butorphanol in controlled-drug log

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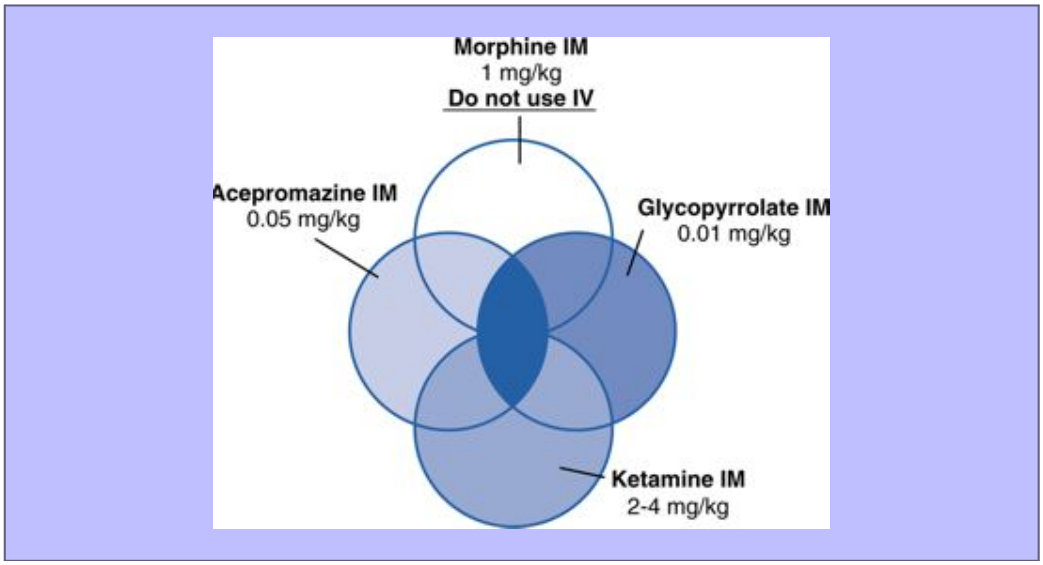

2.4.1.7 Features

- Ideal for very aggressive dogs in good health
- Dogs may vomit; remove muzzle after dogs have been injected and secured in cage or run
- Do not use in old dogs or those with heart or renal disease
- Must record use of morphine and ketamine in controlled-drug log

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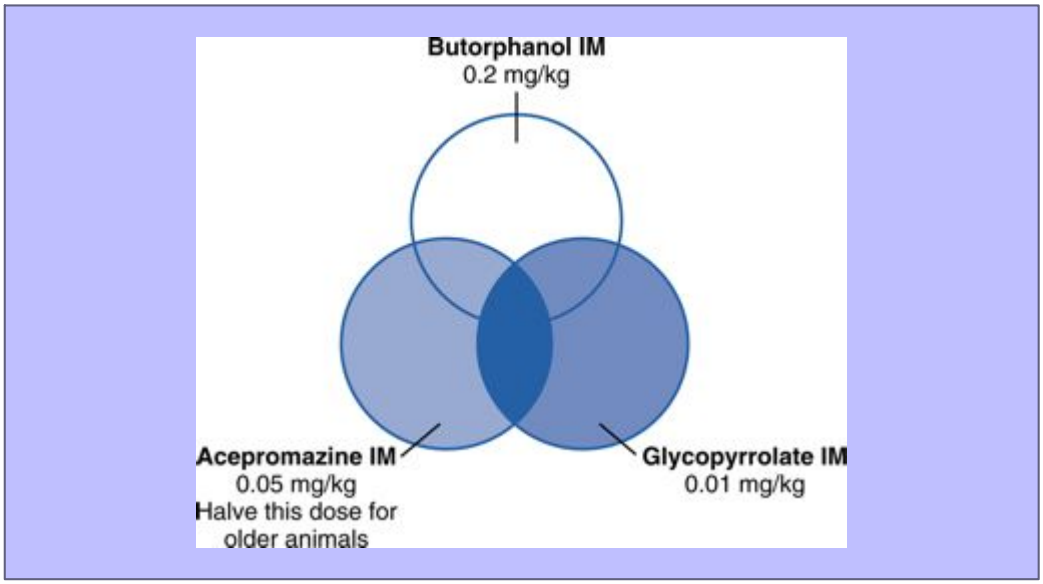
2.5 CATS

2.5.1 IM Sedation

Halve these doses for IV use, but not always practical to use IV in cats.

2.5.1.1 Uses

- Minor procedures (e.g., examinations, wound dressing)
- Premedication before general anesthesia



2.5.1.2 Features

- Suitable for use during most basic procedures (e.g., ovariohysterectomy)
- Produces good sedation in tractable cats, but analgesic effect is not pronounced

- May produce insufficient sedation for anxious or fractious cats
- Must record use of butorphanol in controlled-drug log

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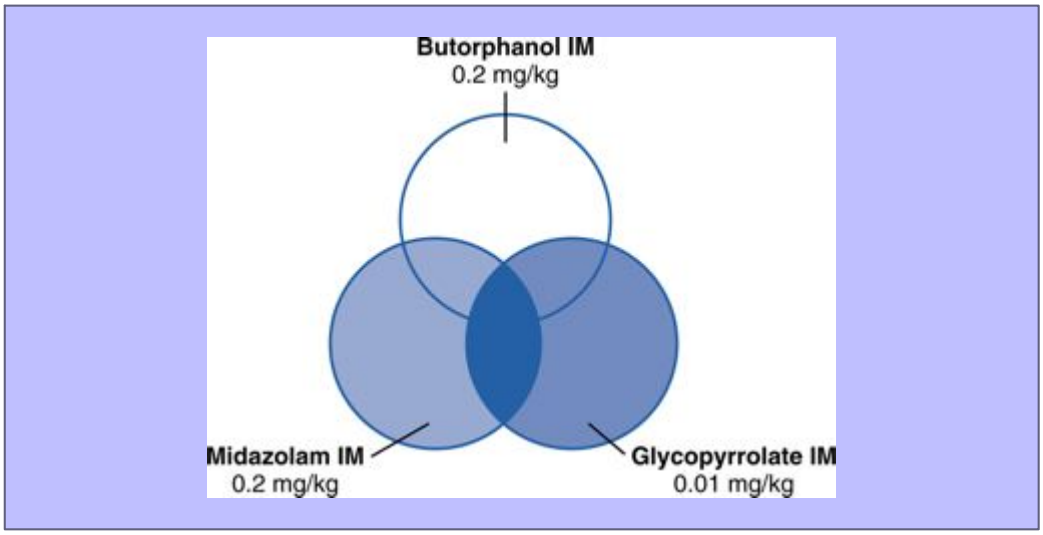
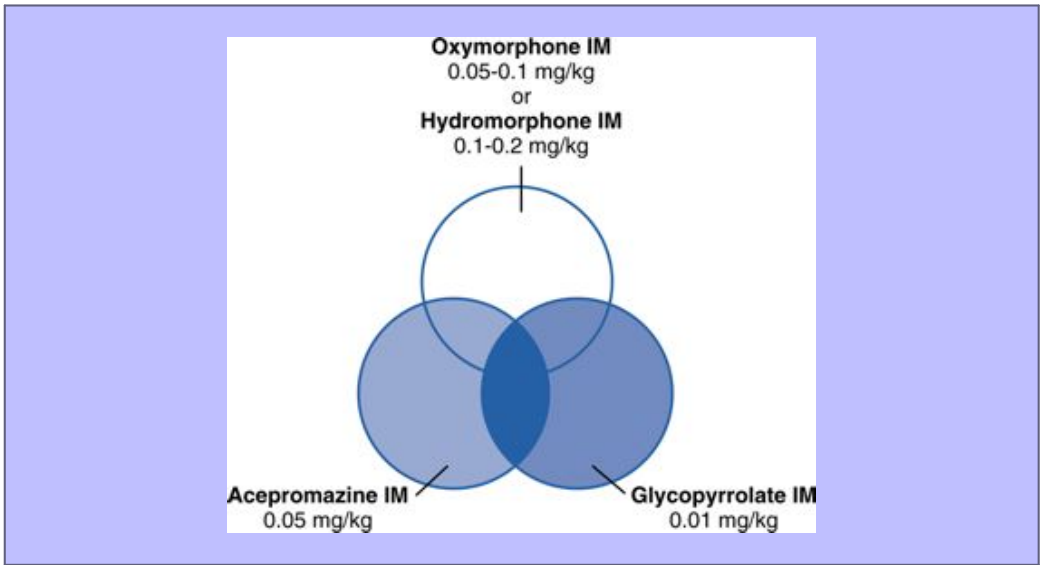


2.5.1.3 Features

- Suitable for use in cats with increased intracranial pressure (e.g., head trauma, brain tumor)
- Do not use for young, healthy cats; excitement and dysphoria occur
- Analgesic effect is not pronounced
- Must record use of butorphanol and midazolam in controlled-drug log



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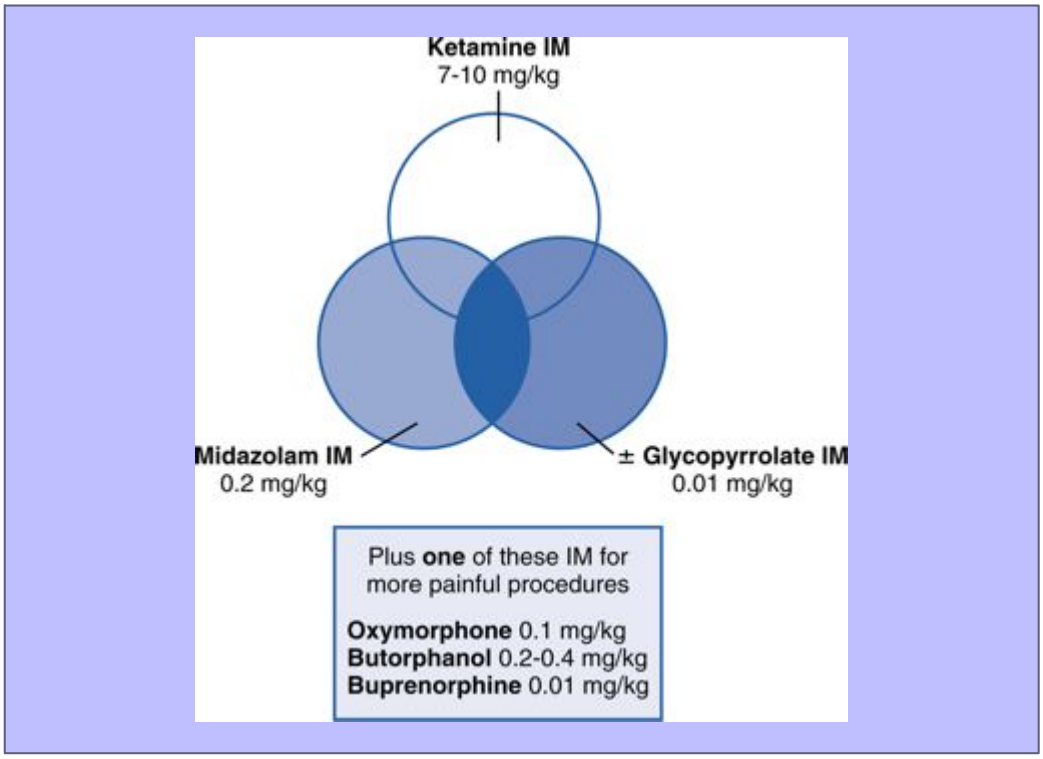
2.5.1.4 Features

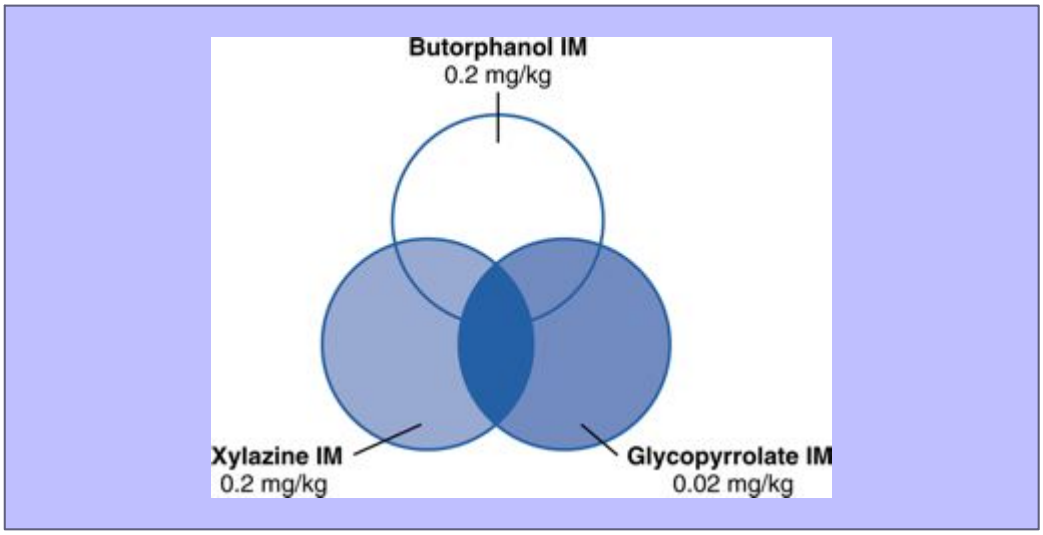
- Suitable for use during more painful procedures
- Suitable for use in anxious or aggressive cats
- Suitable for use in cats with cardiac disease (cardiomyopathy)
- Do not use in hypovolemic animals
- Cats may vomit
- Possibility of mild histamine release if hydromorphone is used IV
- Hypothermia likely; monitor temperature
- Must record use of oxymorphone and hydromorphone in controlled-drug log



2.5.1.5 Features

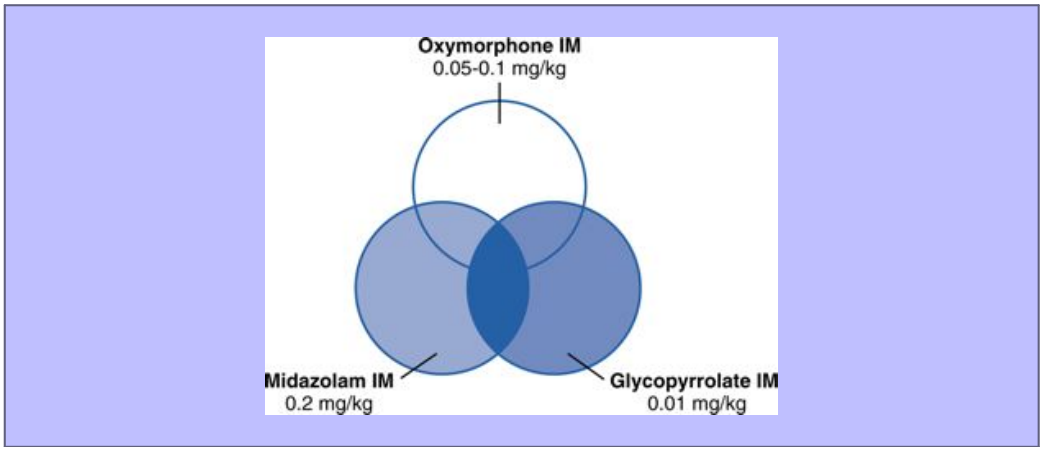
- Not suitable for use in cats with head trauma or history of seizures
- Determine need for glycopyrrolate based on heart rate

- Do not use in cats with heart disease or hyperthyroidism
- Must record use of midazolam, ketamine, and other narcotics in controlled-drug log



2.5.1.6 Features

- Suitable for use in anxious or “caution” cats and those with a history of seizures
- Cats may vomit; suitable for use in cats recently fed or with uncertain fasting history
- Do not use in cats with gut obstruction
- Do not use in diabetic animals
- Do not use in animals with heart disease
- Must record use of butorphanol in controlled-drug log



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2.5.1.7 Features

- Suitable for treatment of painful conditions in older cats
- Suitable for use in debilitated cats
- Insufficient effect in young, healthy cats
- Must record use of oxymorphone and midazolam in controlled-drug log

Butorphanol IM 0.1–0.4 mg/kg	±	Glycopyrrolate IM 0.01 mg/kg

2.5.1.8 Features

- Suitable for use in kittens
- Monitor kittens for respiratory depression
- Suitable for use in geriatric cats
- Suitable for use in cats with significant illness
- Must record use of butorphanol in controlled-drug log

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2.6 RABBITS

2.6.1 IM Sedation

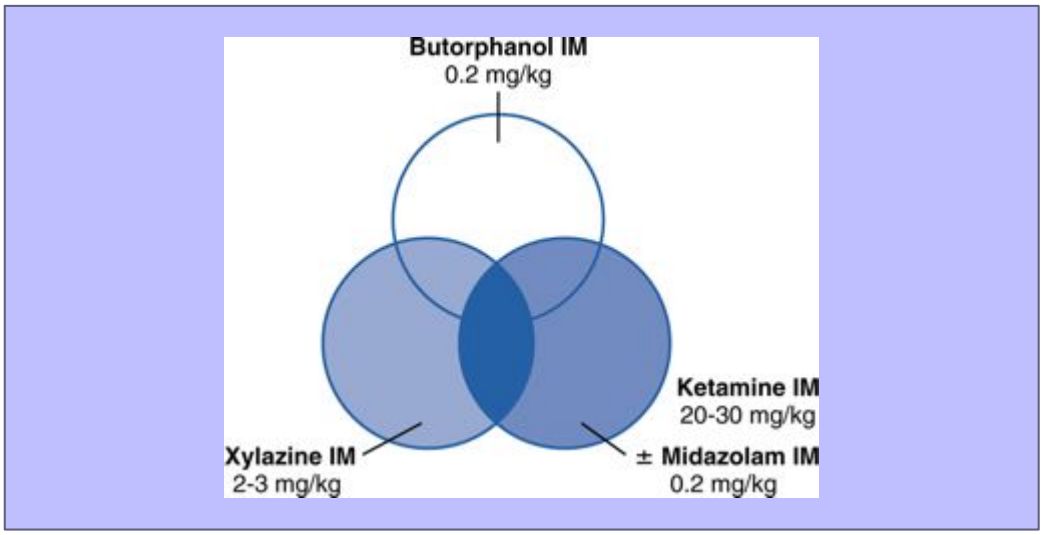
2.6.1.1 Use

- For minor procedures (e.g., examinations, wound dressing)

2.6.2 Premedication before General Anesthesia

2.6.2.1 General Information

- If bradycardia or salivation is problematic, the anticholinergic of choice is glycopyrrolate at 0.01 mg/kg IM or IV; atropine is destroyed rapidly by atropinesterase in many rabbits
- Pet rabbits may have subclinical pulmonary disease
- If the auricular vein is to be catheterized later, apply EMLA cream to the pinna at the time of sedation



2.6.2.2 Features

- Suitable for use during most basic procedures in *healthy* rabbits (e.g., ovariohysterectomy)
- Suitable for use during procedures in which intubation is not essential
- Must record use of butorphanol, ketamine, and midazolam in controlled-drug log

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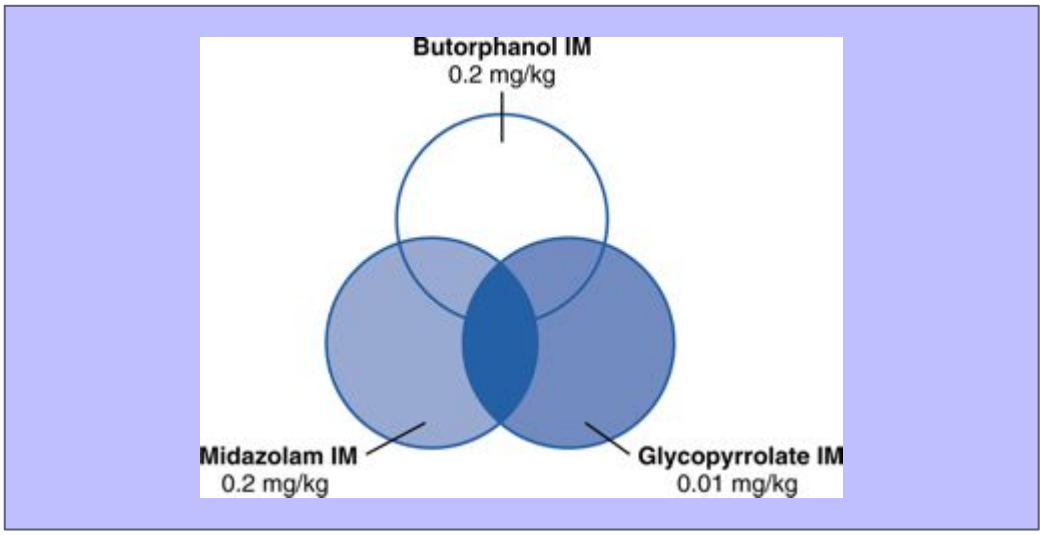


2.6.2.3 Features

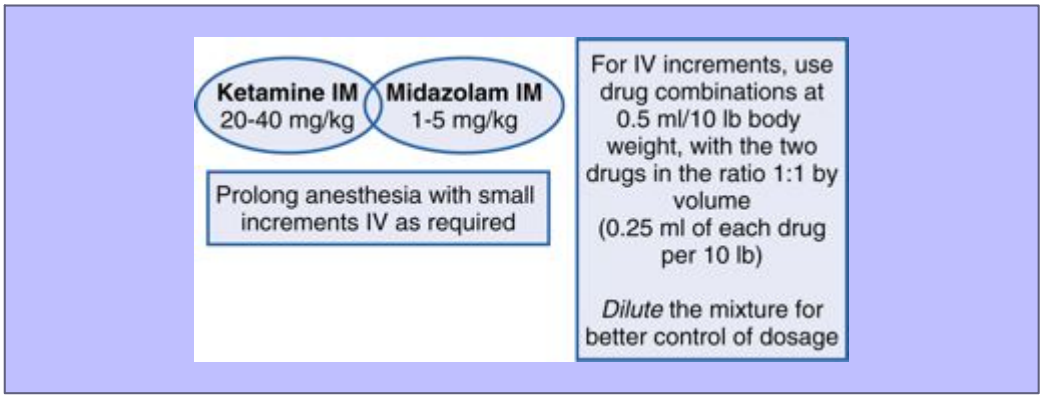
- Suitable for use in ill or debilitated rabbits
- Insufficient effect in young, healthy rabbits

- Analgesic effect is not pronounced
- Must record use of butorphanol and midazolam in controlled-drug log

2.6.3 IM Anesthesia ± IV Maintenance

2.6.3.1 General Information

- If bradycardia or salivation is problematic, the anticholinergic of choice is glycopyrrolate at 0.01 mg/kg IM or IV; atropine is destroyed rapidly by atropinesterase in many rabbits
- Pet rabbits may have subclinical pulmonary disease
- If the auricular vein is to be catheterized later, apply EMLA cream to the pinna at the time of sedation
- Preferable not to use auricular vein for drugs; use cephalic or saphenous vein

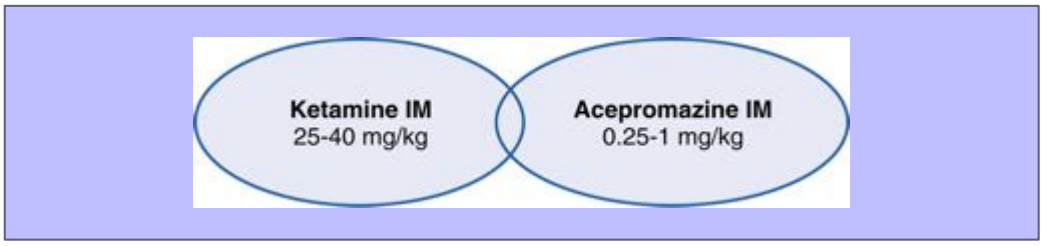


2.6.3.2 Advantages

- Associated with smooth induction and recovery
- Causes good muscle relaxation
- Suitable for use during minor procedures (e.g., radiology, wound dressing, examinations)

2.6.3.3 Disadvantages

- Not suitable for use during major surgery
- Must record use of ketamine and midazolam in controlled-drug log



2.6.3.4 Advantages

- Associated with smooth induction and recovery
- Causes good muscle relaxation

2.6.3.5 Disadvantages

- Must allow sufficient time for acepromazine to take full effect (up to 30 minutes)
- Hypothermia may occur; monitor temperature and keep rabbit warm
- Long duration of acepromazine makes this the least acceptable protocol
- Must record use of ketamine in controlled-drug log

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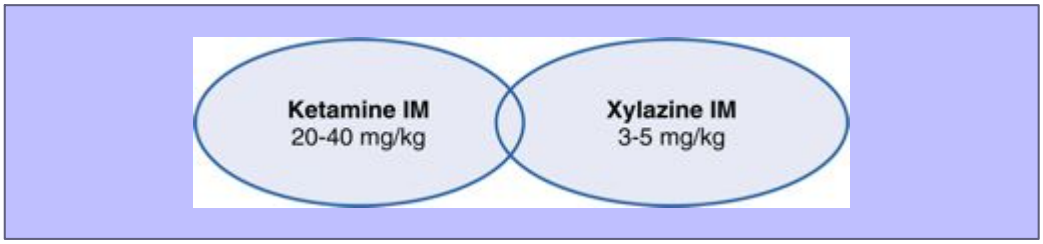

2.6.3.6 Advantages

- Associated with smooth induction and recovery
- Causes good muscle relaxation
- Causes good analgesia
- Can reverse xylazine effects with yohimbine

2.6.3.7 Disadvantages

- Do not use in ill or debilitated animals

- Respiratory depression may occur; potentially problematic in rabbits with subclinical pulmonary pathology
- Hypotension may occur
- Xylazine increases blood glucose; clinical pathology result may be misinterpreted if sample is taken during anesthesia
- Must record use of ketamine in controlled-drug log

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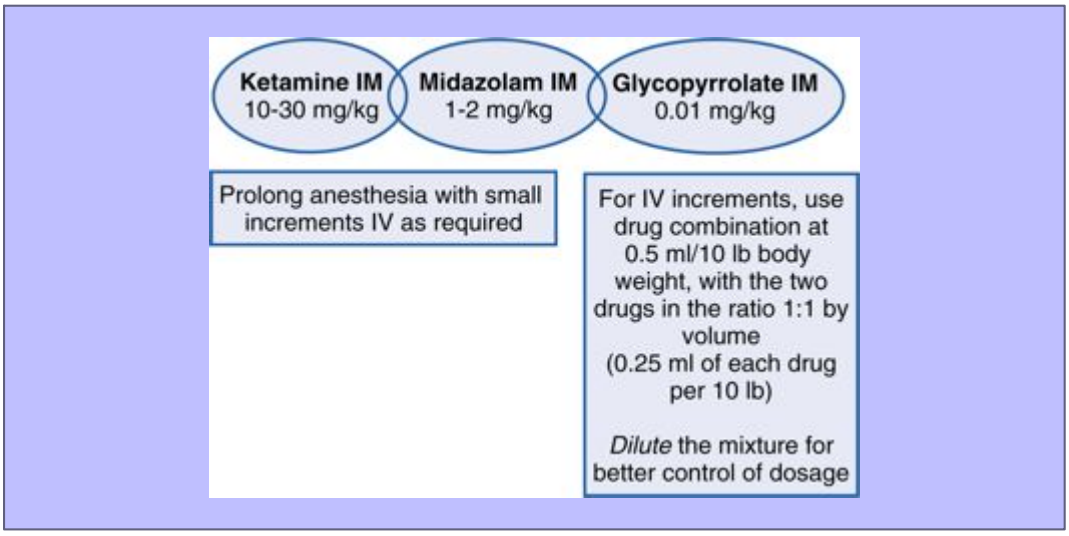
2.7 FERRETS

2.7.1 IM Anesthesia ± IV Maintenance

- Ferrets vomit easily
- Ferrets are often presented for removal of an adrenal tumor or insulinoma; do not fast excessively (e.g., 4 hours maximum)
- Blood pressure may be erratic during anesthesia for adrenalectomy

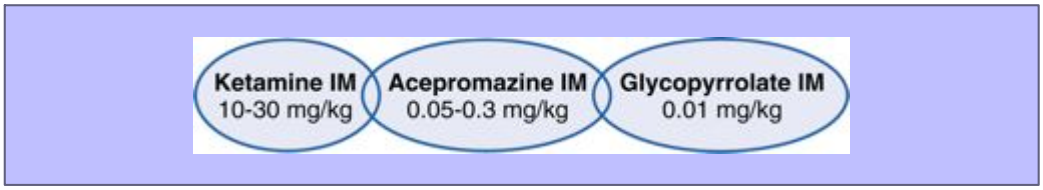


2.7.1.1 Advantages

- Associated with smooth induction and recovery
- Causes good muscle relaxation
- Suitable for use during minor procedures (e.g., radiology, wound dressing, examinations)

2.7.1.2 Disadvantages

- Not suitable for use during major surgery
- Must record use of ketamine and midazolam in controlled-drug log



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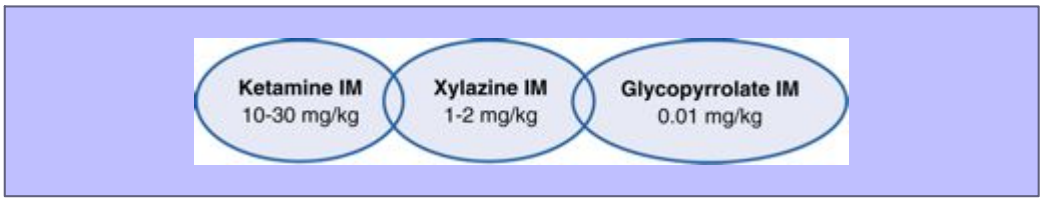
2.7.1.3 Advantages

- Associated with smooth induction and recovery
- Causes good muscle relaxation

2.7.1.4 Disadvantages

- Must allow sufficient time for acepromazine to take full effect (up to 30 minutes)
- Hypothermia occurs; monitor temperature and keep ferret warm
- Long duration of acepromazine make this the least acceptable protocol
- Must record use of ketamine in controlled-drug log



2.7.1.5 Advantages

- Associated with smooth induction and recovery
- Causes good muscle relaxation
- Causes good analgesia

2.7.1.6 Disadvantages

- Do not use in ill or debilitated animals

- Do not use in ferrets with cardiovascular disease
- Do not use in ferrets with endocrine disease; increases blood glucose
- Respiratory depression may occur
- Hypotension may occur
- Must record use of ketamine in controlled-drug log

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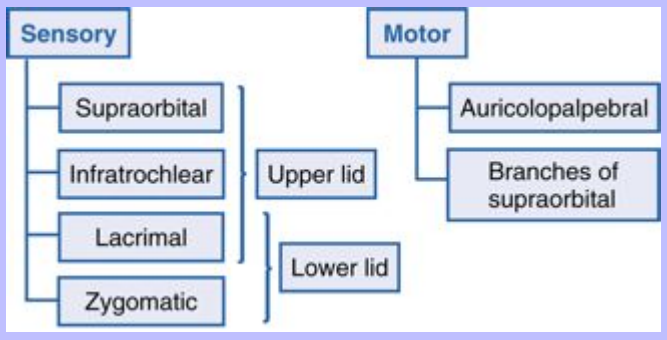
3 Chapter 3 Local Nerve Blocks

3.1 EYE BLOCKS IN HORSES

3.1.1 Features

- Specific nerve blocks useful for sensory functions, motor functions, or both
- Allow easier examination of eye
- Allow treatment of some eye conditions without anesthesia
- Eye(s) must be protected from injury, corneal desiccation, and so on, after procedure is finished, especially after motor blocks

Nerve supply to horse eye.



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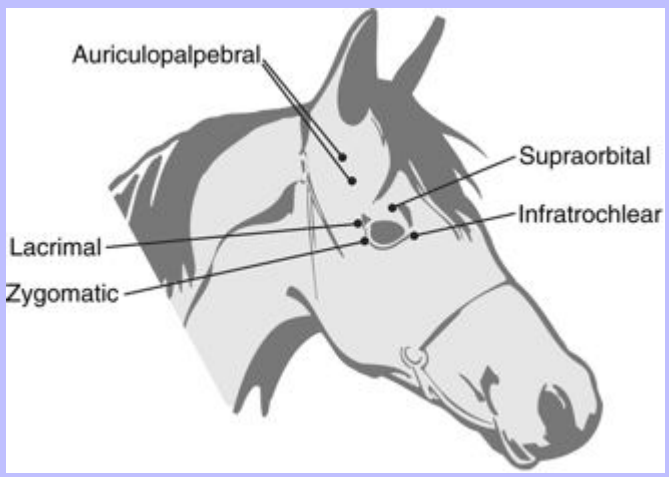
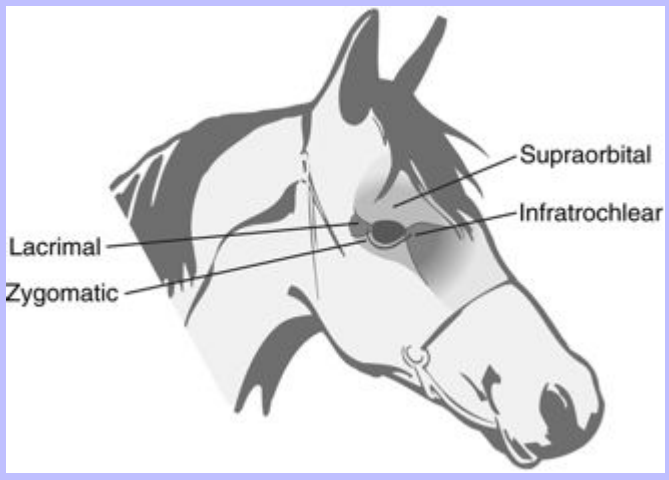
Injection sites for sensory and motor eye blocks in the horse.



Desensitized areas of eyelids of horse after blockade at the corresponding nerve sites.



3.1.2 Drug(s) to Use

- Lidocaine 2%
- Lidocaine 2% + bupivacaine 0.5% (for longer duration)

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- When mixing drugs, use ratio of 1:1 by volume

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- Bupivacaine alone requires longer time for onset; not always practical

3.1.3 Technique

3.1.3.1 Supraorbital Nerve

- Supraorbital foramen
- Palpate supraorbital process of frontal bone, dorsal to eye
- Foramen is palpable approximately 5 to 7 cm dorsal to medial canthus
  - Inject 1 ml into foramen, then another 2 ml as needle is withdrawn into subcutaneous tissue (22-gauge needle)

3.1.3.2 Infratrochlear Nerve

- Infratrochlear foramen

- Dorsal rim of orbit, almost at medial canthus
- Inject 1 ml into foramen, then another 2 ml as needle is withdrawn

3.1.3.3 Lacrimal Nerve

- Dorsal rim of orbit, approximately 1 cm dorsal to lateral canthus
- Inject 1 ml into foramen, then another 2 ml as needle is withdrawn

3.1.3.4 Zygomatic Nerve

- Ventral rim of orbit, approximately 0.5 cm ventral to lateral canthus
- Inject 1 ml into foramen, then another 2 ml as needle is withdrawn

3.1.3.5 Auriculopalpebral Nerve

- Two sites between eye and base of ear, along zygomatic arch
- Can inject at each site or use single injection to cover both sites and area between them
- Useful for examinations, temporary relief of spasm

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- With addition of topical anesthesia, useful for removal of foreign bodies and for subconjunctival injections

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- *No sensory block occurs with this nerve block*
- *Protect cornea from desiccation after procedure is completed*
- Locate zygomatic arch
- For dorsal site, inject 2 ml of drug approximately 3 cm ventral to highest point
- For ventral site, inject 2 ml of drug at dorsal rim of supraorbital process
- For single injection, inject at dorsal site and redirect needle to cover area between locations, using 5 ml total

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3.2 DENTAL BLOCKS IN DOGS AND CATS

3.2.1 Materials Required for All Dental Blocks

- Syringe containing 1 to 2 ml of the following:
  - 2% lidocaine

- or 0.5% bupivacaine
- or 1% mepivacaine

- 25- to 27-gauge needle, 1½ to 1¾ inches for infraorbital block
- Volume (1 vs 2 ml) depends on size of animal
- Use chosen volume as the total volume for all blocks that will be performed at the same time
- Epinephrine (1:200,000) may be added to the local anesthetic to prolong the block
- An aspiration syringe is convenient and accommodates commercially available ampules of local anesthetic*
- Commercially available ampules can be purchased either with or without epinephrine

Aspiration syringe.

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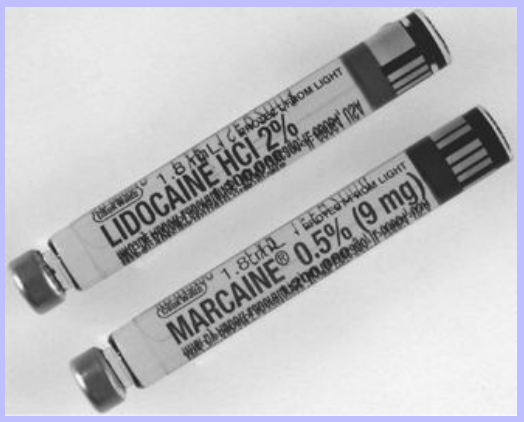
Ampules of local anesthetic for use in aspiration syringe.



* Syringe and ampules available from Henry Schein, Inc., 135 Duryea Rd., Melville, N.Y. 11747; 1-800-872-4346; http://www.henryschein.com.

3.2.2 Drug Comparisons

Drug	Amount of Drug (mg/ml)	Approximate Onset (min)	Approximate Duration (hr)	Convulsive Dose in Dogs (mg/kg IV)
Lidocaine, 2% (Xylocaine)	20	10–15	1–2	11
Bupivacaine, 0.5% (Marcaine)	5	20–30	2.5–6	3.5–4.5
Mepivacaine, 1% (Carbocaine)	10	5–10	2–2.5	29

3.2.3 Technique

- Always aspirate after needle placement
- If blood is aspirated, withdraw the needle and redirect, then reaspirate
- Inject only if blood is no longer aspirated

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- Blocks can be repeated at the end of long procedures to provide longer duration of analgesia during recovery from anesthesia

3.2.4 Upper Teeth

3.2.4.1 Infraorbital Nerve Block

This unilaterally blocks the following:

- Upper teeth anterior to the infraorbital foramen
- Upper lip
- Nose
- Roof of nasal cavity
- Skin anterior to infraorbital foramen

Inject at infraorbital foramen on lateral side of maxilla, anterior to the orbit. To find the infraorbital foramen, do the following:

- For dogs, press on the gum just above and slightly anterior to the mesial root of the fourth premolar tooth and feel for a depression just above the junction of lip and gum
- For cats, press on the gum and feel for a depression at the anterior aspect of the zygomatic arch, just above the third premolar tooth

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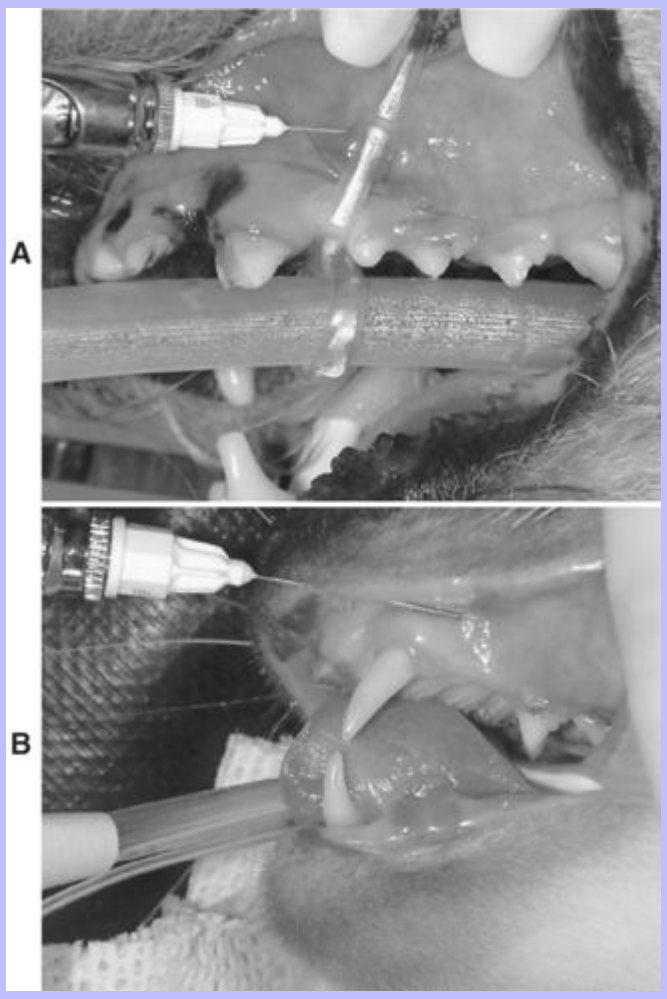
A, Infraorbital nerve block in a dog. **B,** Infraorbital nerve block in a cat.



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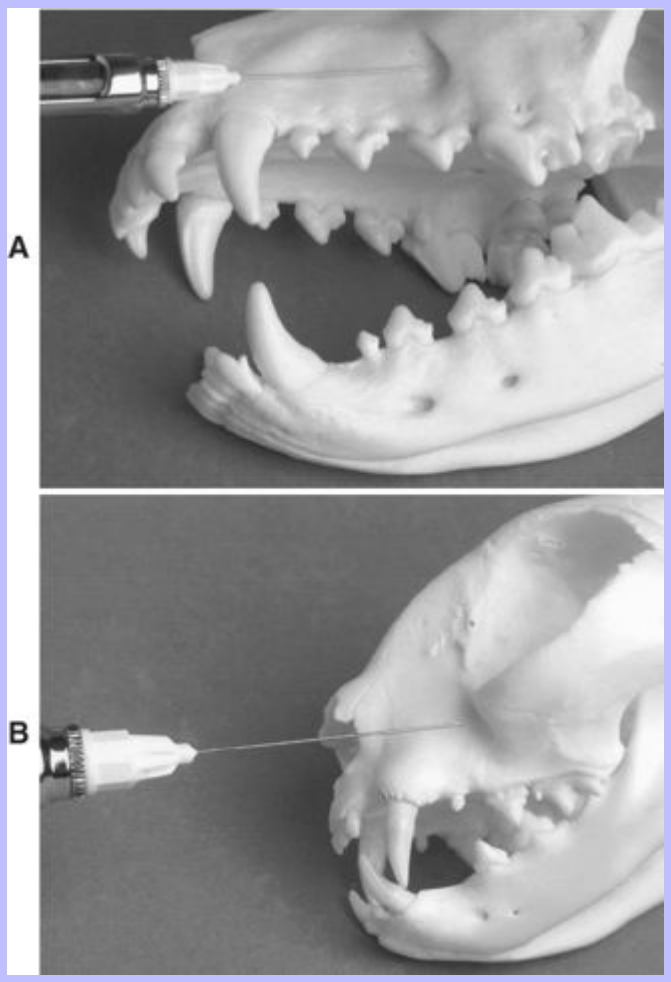
A, Injection site for infraorbital foramen in a dog. **B,** Injection site for infraorbital foramen in a cat.



3.2.5 Lower Teeth

3.2.5.1 Mental Nerve Block

This unilaterally blocks the following:

- Lower teeth anterior to the mental foramen
- Lower lip
- Skin anterior to mental foramen

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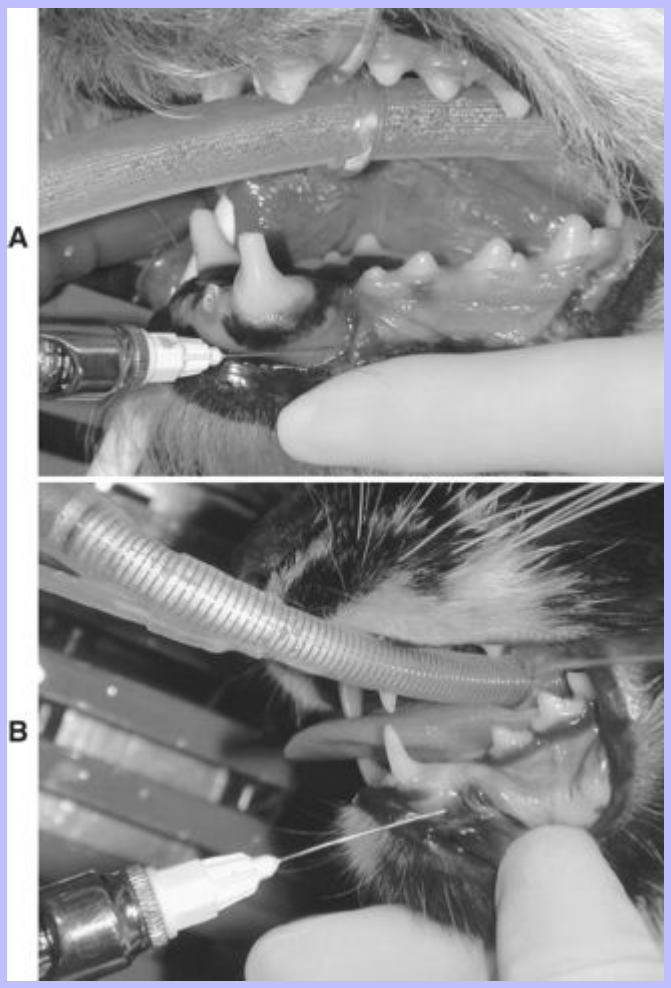
Inject at mental foramen on lateral side of anterior portion of ramus of mandible. Feel for a depression in the gum below the first premolar and just below the junction of lip and gum.

A, Mental nerve block in a dog. **B,** Mental nerve block in a cat.



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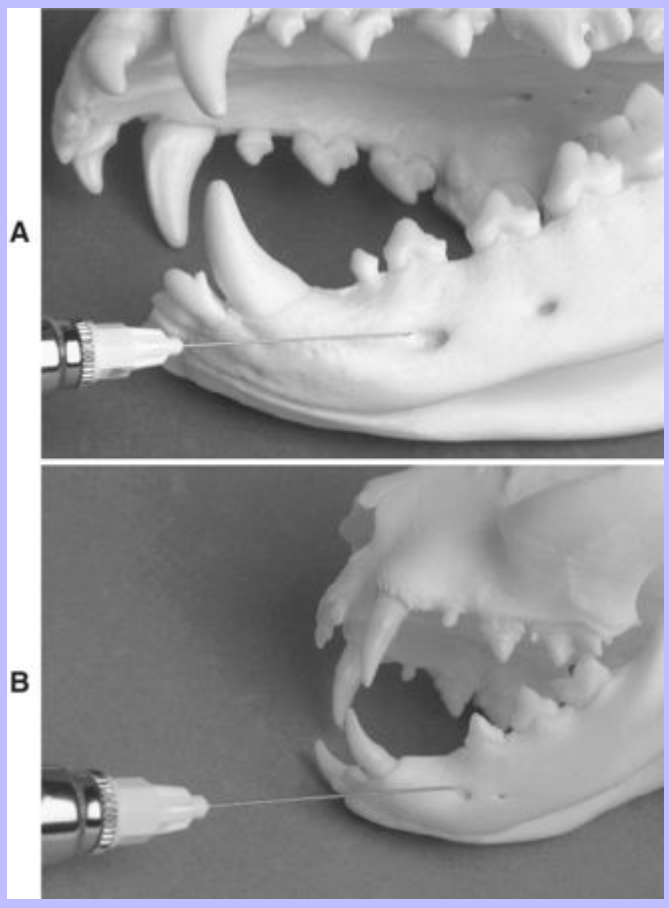
A, Injection site for mental foramen in a dog. **B,** Injection site for mental foramen in a cat.



3.2.5.2

Mandibular Nerve Block

This unilaterally blocks the following:

- Lower teeth
- Lower lip
- Tongue
- Skin anterior to mandibular foramen

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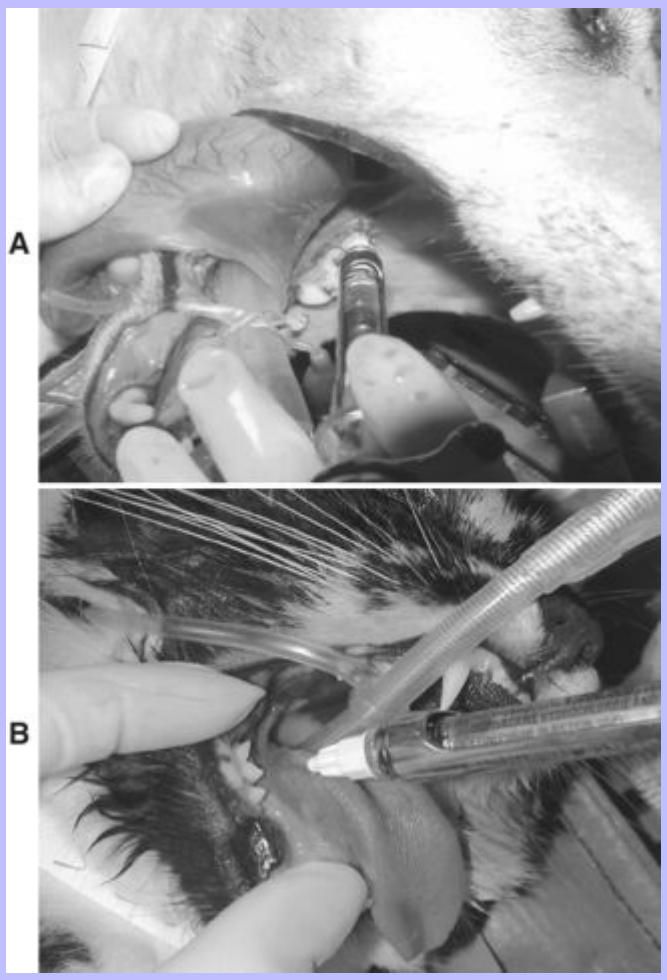
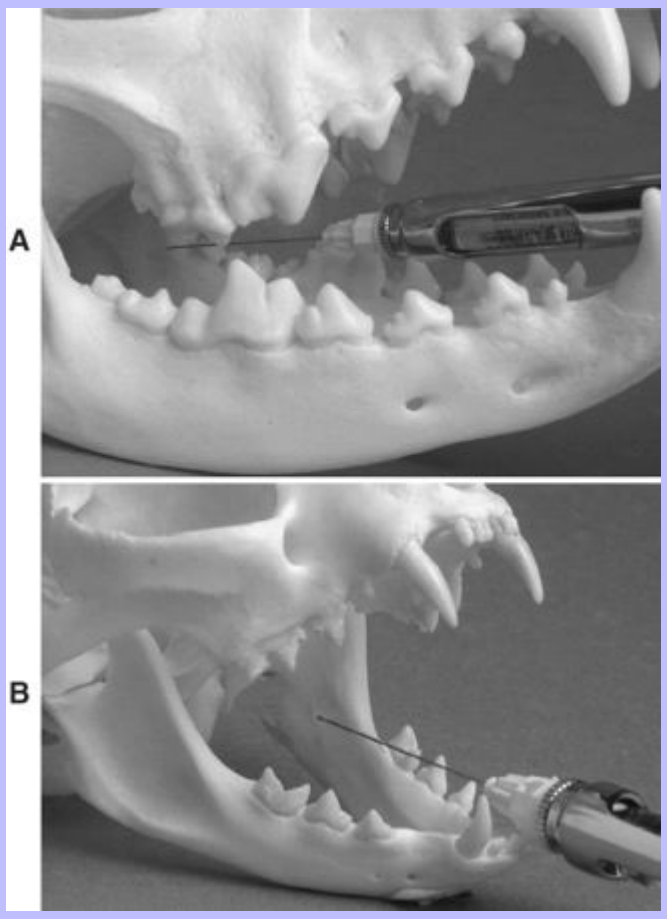
Inject at mandibular foramen on medial side of posterior portion of ramus of mandible. Insert the needle medial to the lower molars and direct it posteriorly to “skim” along the bone. The foramen has a bony lip at its anterior border. Continue just past this point and inject.

A, Mandibular nerve block in a dog. **B,** Mandibular nerve block in a cat.



An alternative technique is to start from the ventral aspect of the ramus of the mandible and inject medially.

A, Injection site for mandibular foramen in a dog. **B,** Injection site for mandibular foramen in a cat.



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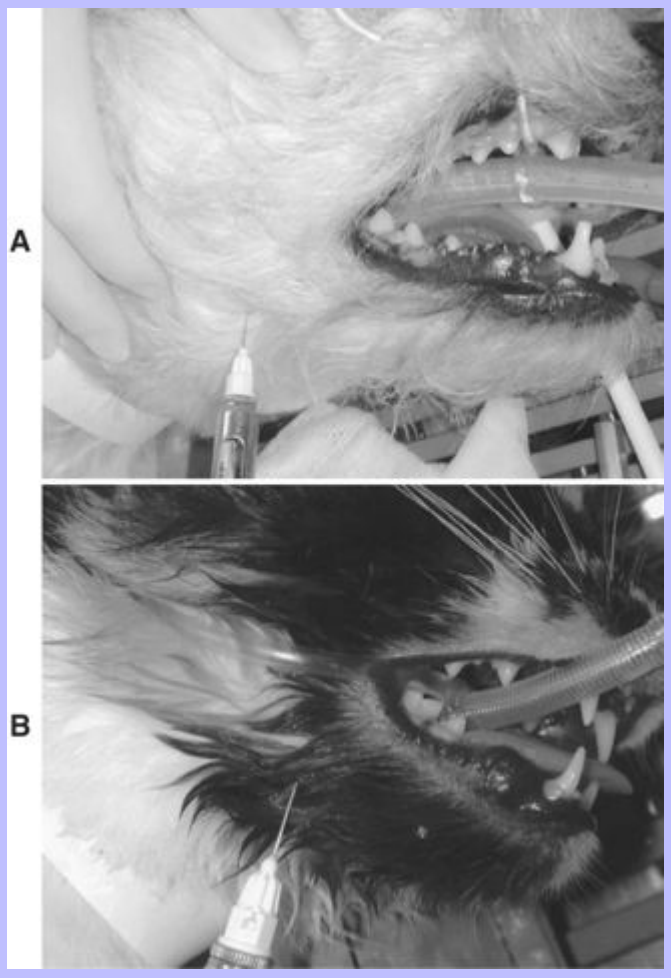
A, Alternative mandibular nerve block in a dog. **B,** Alternative mandibular nerve block in a cat.



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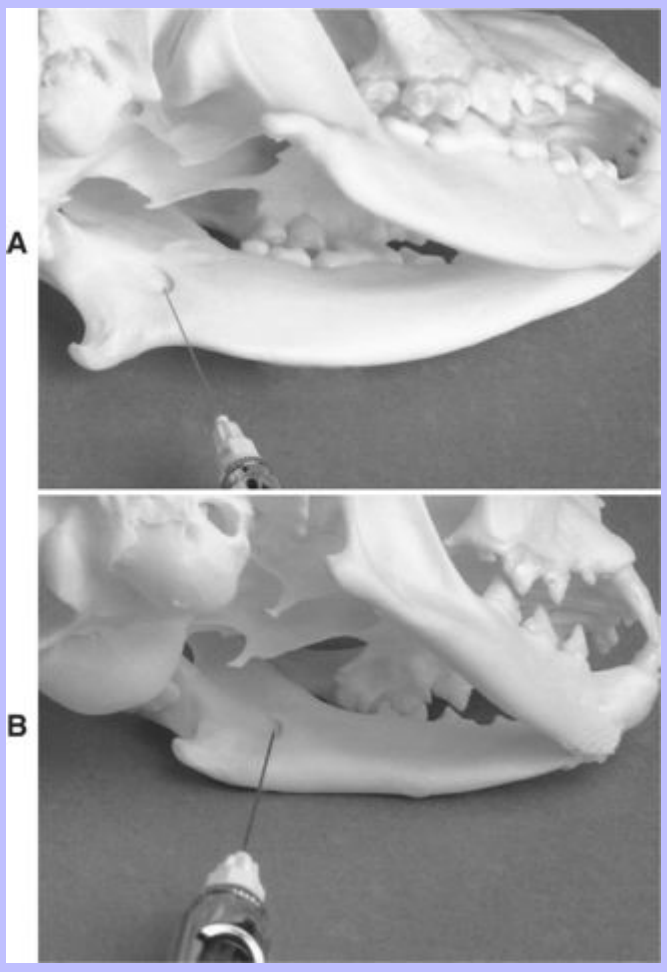
A, Alternative injection site for mandibular foramen in a dog. **B,** Alternative injection site for mandibular foramen in a cat.



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3.3 DEHORNING OF CATTLE, SHEEP, AND GOATS

3.3.1 Features

- Specific nerve block is more useful in cattle than in sheep and goats
- Ring block may be more practical in sheep and goats because of more variable location of nerves; an arc is injected near anterior border of horn to affect all nerves that supply horn
- Occasional failure may result in some animals because of nerve supply from deep branch of the nerve to the frontal sinus, which cannot be blocked

- Sedation may be necessary in some animals

3.3.2 Nerve Supply to the Horn

- Trigeminal nerve
  - Ophthalmic division
    - Frontal nerve (innervates the horn in only a small number of animals)
  - Ophthalmic division
    - Zygomaticotemporal (lacrimal) portion
      - Cornual nerve
- Infratrochlear nerve
  - Cornual branch

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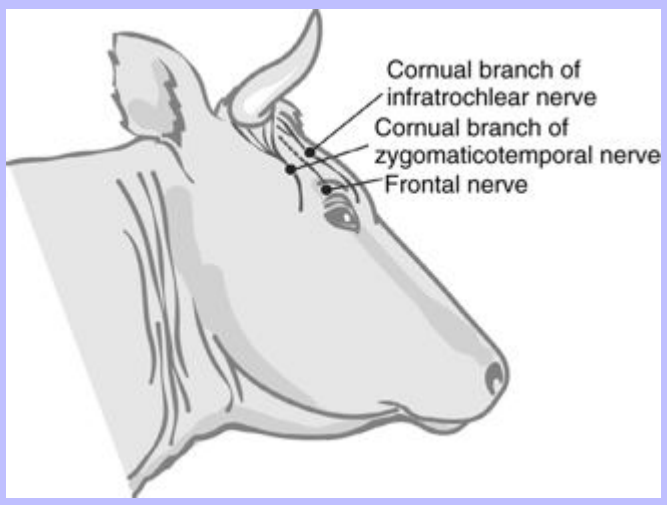
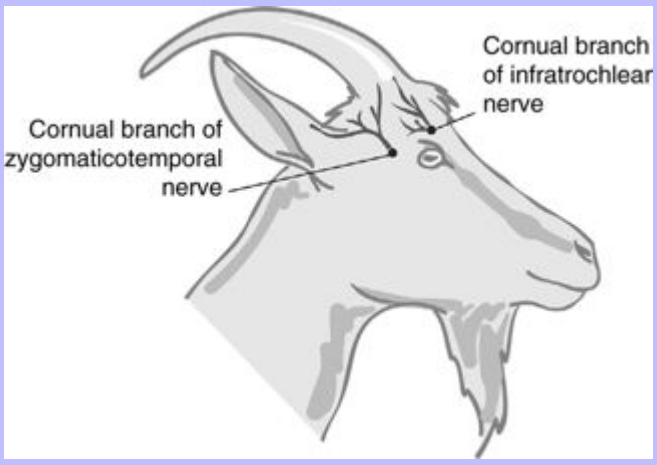
Sites for injection of local anesthetic for dehorning of cattle. The frontal nerve innervates the horn in only some animals.



Sites for injection of local anesthetic for dehorning of goats. Because of the variable nature of the nerve supply in goats, supplementary injections may be necessary around the base of the horn to ensure complete block.



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3.3.3 Drugs to Use

- Lidocaine 2%
- Lidocaine 2% + bupivacaine 0.5% (for longer duration)
- When mixing drugs, use ratio of 1:1 by volume
- Bupivacaine alone requires longer time for onset; not always practical

3.3.4 Suggested Total Volume of Local Anesthetic to Use per Horn

Anesthetic	Adult Cattle (ml)	Calves, Sheep, and Goats (ml)
Lidocaine	10–15	3–5
Bupivacaine	5–8	2–3
Lidocaine + bupivacaine	5–8	2–3

3.3.5 Technique

3.3.5.1 To Block Individual Nerves

- Frontal nerve
  - Dorsal rim of orbit near lateral canthus
- Cornual nerve

- Halfway between eye and orbit, immediately ventral to lateral edge of frontal bone

- Cornual branch of infratrochlear
  - Halfway between eye and orbit
  - An alternative site along nerve is at dorsal rim of orbit near medial canthus

3.3.5.2 Using Single Injection to Block All Nerves

- Use long needle (10 cm, 18 gauge) for cattle; use shorter needle (5 cm, 22 gauge) for sheep and goats
  - Halfway between horn and lateral canthus, level with lateral border of frontal bone
  - Direct needle dorsomedially and withdraw slowly while injecting approximately two thirds of total volume
  - Redirect 2 to 3 cm ventrally, close to frontal crest, and inject remaining volume

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3.4 BRACHIAL PLEXUS BLOCK

3.4.1 Overview

Brachial plexus block is suitable for analgesia for surgery on the front limb, within or distal to the elbow. Although in some patients the block may extend above the elbow, it does not do so reliably, and adjunct analgesic techniques should be used in such cases.

- The technique should be performed in a well-sedated or anesthetized animal
- Bupivacaine is the local anesthetic agent of choice because of its longer duration of action compared with lidocaine
- Onset time for motor block is 6 to 15 minutes
- Onset time for sensory block is 18 to 30 minutes
- Duration of analgesia is 2 to 6 hours
- Blocks can be repeated at the end of long procedures to provide longer duration of analgesia during recovery from anesthesia

3.4.2 Species

- Dogs, cats, small ruminants, foals

3.4.3 Anatomy

The brachial plexus is derived from the cervical roots C5, C6, C7, and C8 and the thoracic root T1. The plexus runs from the neck to the axilla, passing between the clavicle and the first rib, forming the median, ulnar, radial, and musculocutaneous nerves. Alongside the axillary artery runs the axillary vein, and care must be taken not to inject into either vessel via aspiration before injection of drug.

3.4.4 Equipment and Considerations

- Syringe containing 1 to 6 ml (depending on size of patient) of local anesthetic
- 18- to 22-gauge spinal needle or 18- to 27-gauge syringe needle depending on size of patient (1 inch for cats and small dogs; 3 inches for large dogs, ruminants, and foals)

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- Volume to use depends on size of animal (e.g., for bupivacaine use 0.5 ml for cat or small dog; administer up to 10 ml in large dog, ruminant, or foal)
- Ensure that dose administered is below toxic dose based on patient weight (see table below)
- Epinephrine (1:200,000) may be added to the local anesthetic to prolong the block

3.4.5 Drug Comparisons

Drug	Concentration (mg/ml)	Approximate Onset (min)	Approximate Duration (hr)	Convulsive Dose in Dogs (mg/kg IV)
Lidocaine, 2% (Xylocaine)	20	2–5	1–2	11
Bupivacaine, 0.5% (Marcaine)	5	6–15	2–6	3.5–4.5
Mepivacaine, 1% (Carbocaine)	10	4–8	2–2.5	29

3.4.6 Technique

- Place animal in lateral recumbency with affected limb up
- Clip and prepare area using sterile technique
- Insert needle medial to shoulder joint and direct it parallel to vertebral column toward the costochondral junction
- Attach syringe containing local anesthetic
- Aspirate to check for presence of air or blood (withdraw and redirect if either is present)
- Inject as the needle is withdrawn and remove needle and syringe together

3.4.7 Nerve Stimulator Technique

- Large motor neurons may be stimulated with the aid of an electrical current
- By observing for muscle twitches, through electrical stimulation of the nerve, the practitioner can position a needle extremely close to the nerve; the accuracy of local anesthetic blocks can be improved through this technique

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Needle placement for canine brachial plexus block. *A*, Sixth cervical nerve. *B*, Seventh cervical nerve. *C*, Eighth cervical nerve. *D*, First thoracic nerve. *E*, Greater tubercle of humerus. *F*, First rib. (From Benson GJ, Lumb WV, Thurmon JC, Tranquilli WJ, eds: Lumb & Jones' veterinary anesthesia, ed 3, Philadelphia, 1996, Williams & Wilkins.)

- Use lowest possible current
- Insert needle near area of maximal muscle twitching; this allows needle to be positioned within 2 to 5 mm of a nerve
- Inject local anesthetic using technique previously described
- Twitching ceases once drug has reached nerve

3.4.8 Contraindications

- Damage or disease of the brachial plexus
- Sepsis in the axilla
- Allergy to local anesthetic drugs

3.4.9 Complications

- Failure to attain complete analgesia
- Arterial or venous puncture
- Pneumothorax (rare)

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3.5 DECLAWING OF CATS

3.5.1 Features

- Specific nerve block is most useful
- Ring block of distal limb at carpal level may be substituted with good results
- Nerve block significantly decreases or eliminates reaction to surgical removal of phalanx; little or no tachycardic response
- Significant improvement in quality of recovery
- Best results with mixture of lidocaine and bupivacaine; rapid onset and long duration

3.5.2 Drugs to Use

- Lidocaine 2%
  - Approximately 0.5 ml per paw
- Bupivacaine 0.5%
  - Approximately 0.5 ml per paw (longer onset)
- Lidocaine 2% + bupivacaine 0.5%
  - Approximately 0.5 ml total per paw, with each drug in ratio 1:1 by volume

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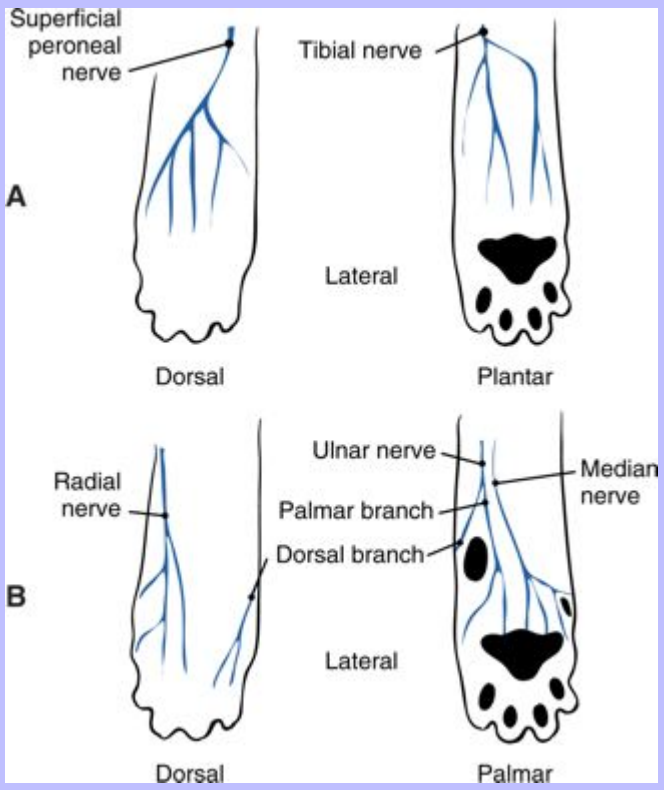
A, Nerves in hind paw of cat. **B,** Nerves in front paw of cat. (From Mathews KA: Management of pain, *Vet Clin North Am Small Anim Pract* 30:853, 2000.)



3.5.3 Technique

- Block one limb at a time for surgery, rather than all limbs at once
- Clip and prepare surgical site
- Use manual pressure to move blood proximally, then apply tourniquet
- Inject at site of nerves at level of carpus
- Alternatively, inject in a fanwise manner across limb at carpal level
- Allow several minutes for drug to take effect
- Remove tourniquet immediately after surgery

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3.6 INTERCOSTAL BLOCK

3.6.1 Indications

- Analgesia of chest wall surrounding incision site during and after thoracotomy
- Likely to improve ventilatory function postoperatively because of pain-free chest wall movement

3.6.2 Drugs to Use

- Lidocaine 2%
  - Approximately 0.25 to 1 ml per injection site
- Bupivacaine 0.5%
  - Approximately 0.25 to 1 ml per injection site
- Lidocaine 2% + bupivacaine 0.5%
  - Approximately 0.25 to 1 ml total per injection site, with each drug in ratio 1:1 by volume
- Epinephrine 1:200,000 can be added to drugs to prolong analgesic effect

3.6.3 Technique

- Perform surgical preparation of skin over proximal area of ribs just below point of rib curvature, to include two intercostal spaces cranial and caudal to incision site
- Insert needle into intercostal space so that needle tip is directed toward caudal edge of rib; a slight angle during insertion may decrease risk of inadvertent puncture of pleura with subsequent pneumothorax or pulmonary trauma; safer than injecting at right angle to skin surface

3.6.4 Precautions

- Pneumothorax may result if pleura is inadvertently punctured
- Multiple injections may result in local anesthetic toxicity; limit total dose to 3 mg/kg each time blocks are performed
- Monitor patient carefully for several hours to ensure adequate ventilation; pneumothorax may develop slowly

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3.7 INTERPLEURAL BLOCK

3.7.1 Indications

- Regional analgesia for thoracic or upper abdominal conditions (e.g., multiple fractured ribs, malignancy)
- Best performed in anesthetized or heavily sedated patient

3.7.2 Materials Required

- Materials for clipping and surgical preparation of skin
- Tuohy needle, 17 gauge, 5 cm × 1.4-mm outer diameter
- Chest tube or interpleural catheter
- Sterile needles and syringes—one for lidocaine, one for bupivacaine

3.7.3 Drugs to Use

- Lidocaine 2%, 1 to 2 ml for anesthesia of skin and subcutaneous tissues
- Bupivacaine 0.5% for interpleural anesthesia
  - Dogs, 0.2 to 0.4 ml/kg
  - Cats, 0.15 ml/kg

3.7.4 Technique

- Perform surgical preparation of skin over rib, usually at upper third of rib
- Inject lidocaine into skin, subcutaneous tissues, and parietal pleura at caudal border of rib
- Insert Tuohy needle and remove stylet
- Fill needle with sterile saline to create hanging drop at hub
- Advance needle carefully to penetrate parietal pleura
  - Drop may disappear during inspiration (not always reliable)
  - Alternatively, penetration of parietal pleura may create a clicking sensation
- Keep needle in this position and advance catheter through needle for several centimeters

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- Attach adapter to end of catheter
- Aspirate for air or blood

- Inject drug slowly and flush in with 1 to 2 ml of sterile saline
- Seal catheter and secure to thoracic wall
- Position patient so that fluid can gravitate to affected area, and keep patient in this position for approximately 10 minutes

3.7.5 Precautions

- Pneumothorax may result if visceral pleura is inadvertently punctured
- Monitor patient carefully for several hours to ensure adequate ventilation; pneumothorax may develop slowly
- Prevent infection by means of strict aseptic technique

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3.8 PARAVERTEBRAL BLOCK IN CATTLE, SHEEP, AND GOATS

3.8.1 Indications

- Regional anesthesia of abdominal wall to allow standing surgery (e.g., correction of abomasal displacement, removal of hardware from rumen, cesarean section)

3.8.2 Materials Required

- Materials for clipping and surgical preparation of skin
- Sterile needles
  - 20-gauge needle for skin anesthesia
  - 18-gauge spinal needle, 4.25 to 15 cm, for muscle-layer anesthesia
- Sterile syringes, 3 ml, 20 ml

3.8.3 Drug to Use

- Lidocaine 2%, 2 to 3 ml for anesthesia of skin
  - 1 ml for sheep and goats
- Lidocaine 2%, 20 ml per injection site for anesthesia of muscle layers
  - 3 ml per injection site for sheep and goats

3.8.4 Technique

- Nerves to be blocked are T13, L1, L2

- Include L3 and L4 for cesarean section; some hindlimb weakness may occur
- Nerves travel in a caudal direction after leaving vertebral foramina, and each crosses the cranial border of the lumbar transverse process caudal to its exit vertebra (e.g., T13 crosses cranial border of transverse process of L1)
- Clip skin from dorsal midline to include area surrounding surgical site
    - If hair is not clipped as high as dorsal midline, it will become wet during scrubbing procedure and allow dripping of contaminated fluid onto drapes and surgical site during surgery 159 160
- Perform surgical preparation of skin

3.8.4.1 Proximal Paravertebral Block

- Palpate outermost border of most anterior lumbar transverse process; this is almost always L2; L1 is short and not easily palpable except in thin cows; easier to palpate in sheep and goats
- With thumb on this border place finger of same hand on dorsal spine of cow so that a line joining thumb and finger is perpendicular to vertebral column; this line overlies cranial border of transverse process
- At a point approximately halfway along this line, inject 2 to 3 ml of lidocaine to anesthetize skin and subcutaneous tissues (20-gauge needle); use 1 ml in sheep and goats
- Insert 18-gauge needle vertically to reach ventral aspect of cranial border of transverse process
    - Muscle spasm may be strong enough to bend needle; may need to inject small volumes of lidocaine while advancing the needle
- Needle may encounter bone of transverse process; if this occurs, “walk” needle off cranial edge and advance approximately 0.5 cm deeper
- Attach syringe and inject three fourths of volume of lidocaine at this location (approximately 15 ml in cattle, 2 ml in sheep and goats)
- Withdraw needle to just dorsal to transverse process and inject remaining volume (approximately 5 ml in cattle, 1 ml in sheep and goats)
    - This procedure has now blocked L1 nerve at L2 transverse process
- Repeat procedure for transverse process of L3
- Measure distance between these two injection sites and use same distance cranial to first injection site for injection at L1 transverse process (to block T13 nerve)
- Repeat injections as described for required number of nerves 160

3.8.4.2 Distal Paravertebral Block

- Injections are made using a lateral approach to outermost border of transverse processes of L1, L2, and L4
    - Because of the anatomy of this area, injection at L4 using a lateral approach blocks L2 and L3 nerves
- Keeping syringe and needle horizontal, insert needle to the ventral aspect of lumbar transverse process
- Inject approximately three fourths of volume of lidocaine in a fan-shaped manner
- Withdraw slightly and redirect slightly caudally and dorsally to transverse process
- Inject remaining volume
- Repeat for each site

3.8.5 Signs of Success

- No reaction to needle pricking of skin
- Warmth of skin on injected side
    - Paralysis of cutaneous vasomotor nerves
- Scoliosis
    - Paralysis of paravertebral muscles

3.9 EPIDURAL BLOCKS

3.9.1 Indications

- Anesthesia of the body caudal to the umbilicus to allow surgery (e.g., cesarean section)
- Postoperative analgesia (e.g., orthopedic procedures on hindlimbs, anal sacculectomy)
- Relief of tenesmus (e.g., rectal prolapse)

3.9.2 Precautions

- Sterile preparation of the area is imperative
- Avoid in patients with coagulopathy, those receiving anticoagulant medications, and those with skin irritation or infection in the lumbosacral area
- Assure patient has normal urination after administration of epidural opioids

3.9.3 Skeletal Formulas, Termination of Spinal Cord, and Usual Site of Epidural Injection by Species

	Skeletal Formula						
Species	**C**	**T**	**L**	**S**	**Co**	**Termination of Spinal Cord**	**Caudal Epidural Site**
Horses	7	18	6	5	15–21	S2	C1–2
Cows	7	13	6	5	18–20	S1	C1–2*
Sheep	7	13	6–7	4	16–18	S1	C1–2
Goats†	7	13 (12)	6 (5)	5 (4–6)	7–12	S1	C1–2
Pigs	7	14–15	6–7	4	20–23	S1–2	L6-S1
Dogs	7	13	7	3	20	L6–7	L7-S1
Cats	7	13	7	3	Variable	L7-S3	L7-S1
Rabbits	8	12	7	4	6	S2–3	L7-S1
Ferrets	7	15	5–7	3	18	L7	L7-S1

C, Cervical; *Co*, coccygeal; *L*, lumbar; *S*, sacral; *T*, thoracic.

* S5-C1 can also be used.

† Variation in number of vertebrae (except cervical) is common; alternative numbers are in parentheses.

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3.9.4 Drugs Used

- Local anesthetics
  - Block both sensory and motor nerve transmission
- Opiates
  - Block only sensory nerve transmission
- Xylazine
  - Blocks sensory nerve transmission and may block motor nerve transmission (lesser effect)
- Some systemic absorption of all agents can occur, and systemic side effects are related to the agent used

3.9.5 Doses of Agents That Can Be Used for Epidural Blockade

Species	Lidocaine (mg/kg)	Xylazine (mg/kg)	Preservative-Free Morphine (mg/kg)
Horses	0.25	0.25	0.1
	0.22 (lidocaine) +	0.17 (xylazine)	
Cattle	0.22	0.05	0.1
Sheep	0.22	0.03	0.1–0.2
Goats	0.22	0.03	0.1–0.2
Pigs	0.22	0.17–2	0.1–0.2
Dogs	4	0.02	0.1–0.2
Cats	2.5	0.02	0.05–0.1
Rabbits	0.22*	0.02	0.1–0.2
Ferrets	0.22	NA	0.05–0.1

NA, Not applicable.

* Lidocaine may not be suitable for rabbits; because this species relies so heavily on hindlimb function for locomotion, slow return of motor function may cause distress and panic with possible injury.

3.9.6 Materials Required for Epidural Block

- Syringe for epidural analgesic agent
  - Local anesthetic
  - Preservative-free morphine
  - Xylazine (usually in horses or cattle; may be combined with local anesthetic)
- Loss-of-resistance syringe if using lateral recumbency

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- 18- to 27-gauge spinal or epidural needle, ½ to 3 inches depending on patient size
  - 18-gauge needle for horses, cattle
  - 20-gauge needle for medium to large dogs; 22-gauge needle for cats and small dogs
  - 22- to 27-gauge needle for rabbits, ferrets
- Epinephrine (1:200,000) may be added to the local anesthetic to prolong the block; commercially available ampules of local anesthetics can be purchased either with or without epinephrine
- Materials for clipping and surgical preparation of skin
- Sterile gloves, drape, and surgical cap and mask

3.9.7 General Points

- Animals of large species are usually injected while they are standing and adequately restrained; sedation may be required in certain cases, depending on the temperament of the animal and the procedure to be performed

- Animals of small species are either sedated or anesthetized first
- In the ideal situation the anesthetized patient lies with the affected side down for 10 to 20 minutes to allow the drug to have sufficient effect on nerve roots; this is not always practical
- Anesthetized or recumbent animals can be positioned in either sternal or lateral recumbency
    - Sternal recumbency has the following characteristics
        - Allows the “hanging drop” method to be used to indicate correct placement
        - Is easier for beginners to find the anatomic landmarks
        - Positioning in sternal recumbency
            - The hindlimbs can be frog-legged underneath the animal, or they can be drawn forward beside the trunk to allow greater opening of the lumbosacral space
            - It is essential to have the animal positioned vertically and not tilted

    - Lateral recumbency
        - “Hanging drop” method cannot be used; must use loss of resistance to confirm correct placement
        - Situations occur in which the animal cannot be placed sternally with the legs underneath or beside it
            - A shattered leg that requires surgery but that can be made far worse by manipulation of the limb
            - Cesarean section in a sow that requires an epidural block
        - Positioning in lateral recumbency
            - The animal is placed laterally and the legs drawn forward as far as possible (not practical in sows)
            - The same landmarks and injection technique are used as for sternal recumbency

3.9.8 Hanging Drop Technique

The hanging drop technique involves removing the stylet of the spinal needle, filling the hub of the needle with saline or anesthetic solution, and allowing one drop to hang from the hub. As the needle is advanced through the ligamentous structures, the drop does not move. However, on penetration of the ligamentum flavum, the negative pressure in the epidural space draws the drop of solution into the needle, indicating proper placement in the epidural space. A “pop” is usually felt through the needle when the spinal needle is passed through the ligamentum flavum. The chance for a successful hanging drop technique is greater in large dogs than in smaller dogs and cats. If the hanging drop technique fails, the loss-of-resistance technique can be used.

3.9.9 Loss-of-Resistance Technique

- Fill syringe with small volume of air (e.g., from 3 ml in large animal species to 0.1 ml in rabbits and ferrets)

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- No resistance to injection indicates correct placement

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3.9.10 Horses

- Use an 18-gauge spinal needle, 5 to 7.5 cm long
- Raise and lower tail while feeling for midline depression just caudal to sacrum
- Insert needle at right angle to the croup surface or with the needle tip pointing slightly cranially
- Inject drug slowly and wait 10 to 30 minutes for full effect
- Approximate volumes of drug required for 450-kg horse:
  - Lidocaine 2%, 6 to 8 ml
  - Xylazine 10%, 0.77 ml diluted to 10 ml with 0.9% NaCl
  - Lidocaine 2%, 5 ml + xylazine 10%, 0.77 ml

3.9.11 Cattle, Sheep, and Goats

- Use an 18-gauge spinal needle, 3.5 to 5 cm (cattle), 2.5 to 3.75 cm (sheep, goats)
- Raise and lower the tail while feeling midline depression between first and second coccygeal verterbrae
- This site is larger and easier to penetrate than S5 through first coccygeal vertebra
- Insert needle at right angle to the skin surface or with the needle tip pointing slightly cranially
- Inject drug slowly and wait 10 to 20 minutes for full effect
- Approximate volumes of drug required:
  - Cattle
    - Lidocaine 2%, 1 ml/100 kg
    - Xylazine 10%, 0.25 ml/100 kg diluted to 5 ml with sterile water
    - Side effects will be seen (e.g., sedation, ruminal amotility, bradycardia)

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  - Xylazine 10%, 0.15 ml/100 kg + lidocaine 2%, sufficient to make total volume of 5 ml
    - Useful for more cranial procedures (e.g., rumenotomy, cesarean section)

- Moderate ataxia occurs

- Sheep and goats
  - Lidocaine 2%, 1 ml/50 kg

3.9.12 Pigs

- Spinal needle size depends on size of pig
  - Pigs up to 260 kg, 14-gauge, 6- to 8-cm needle
  - Pigs over 1060 kg, 18-gauge, 10- to 16-cm needle
- Imagine a transverse line joining iliac crests
- Feel for midline depression caudal to this line at a distance that depends on size of pig:
  - 0.5 to 1.5 cm in pigs up to 50 kg
  - 1.5 to 2.5 cm in larger pigs
- Alternatively, imagine a vertical line from patella
  - Midline depression is 2 to 3 cm caudal to line
- Insert needle with the needle tip pointing cranially, approximately 20 degrees to vertical
- Inject drug slowly and wait 10 minutes for full effect
- Approximate volumes of drug required:
  - Lidocaine 2%, 1 ml/4.5 kg (20 ml maximum volume)
  - Xylazine 10%, 2 ml/100 kg, diluted to 5 ml with 0.9% NaCl
  - Xylazine 10%, 1 ml/100 kg + lidocaine 2%, sufficient to make total volume of 10 ml

3.9.13 Dogs and Cats

- Spinal cord ends in cauda equina at a more caudal location in the cat than in the dog; this means that cerebrospinal fluid (CSF) often is encountered in cats but rarely in dogs

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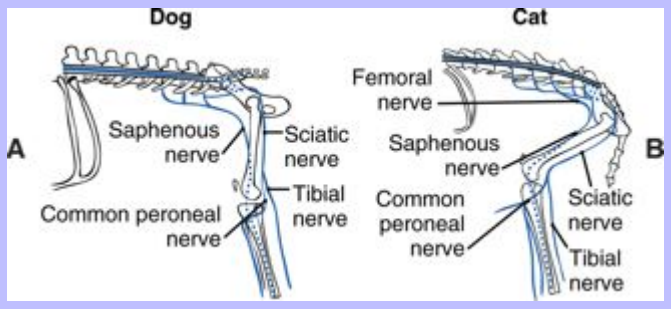
Relationship of spinal cord to vertebral column in **A,** dog and **B,** cat. (From Mathews KA: Management of pain, *Vet Clin North Am Small Anim Pract* 30:850, 854, 2000.)



- Spinal needle size depends on size of patient
  - Large dogs, 18-gauge, 7.5-cm needle
  - Medium dogs, 20-gauge, 3.8-cm needle
  - Small dogs and cats, 22-gauge, 2.5-cm needle
- Use the thumb and second finger of the nondominant hand to feel the iliac crests on either side of the midline
- Keeping these digits in position on these crests, use the index finger of the same hand to feel the depression in the midline just caudal to the dorsal spinous process of L7; move the index finger cranially and caudally to confirm the correct location of the space
- Using the dominant hand, insert the needle into this space perpendicular to the skin surface and exactly in the midline (i.e., not tilting to either side)
- Steadily push the spinal needle inward until a fairly firm resistance is felt; this is the ligamentum flavum

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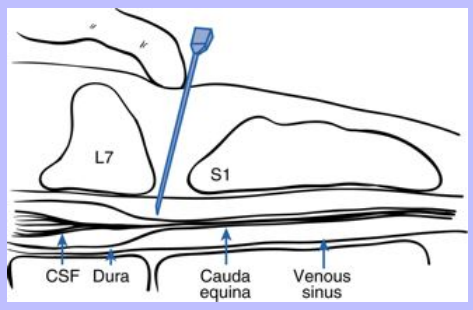
Correct needle placement for epidural injection in the dog. (From Mathews KA: Management of pain, *Vet Clin North Am Small Anim Pract* 30:861, 2000.)



- Place several drops of drug into the hub of the spinal needle; as the needle is pushed through the ligament the drug is drawn down the needle and disappears from the hub; this confirms that the needle point is now in the epidural space
- As the needle is pushed in farther a bony resistance may be felt; this is the floor of the vertebral canal; withdraw the needle slightly and aspirate to ensure that a blood vessel has not been penetrated and to check for the presence of CSF
- Inject drug slowly; there should be no resistance to injection
- *If resistance is felt* it usually means that the needle is positioned against bone or has not penetrated the ligament; readjust the position slightly and aspirate before continuing
- *If blood is encountered,* do not inject; withdraw the needle further and aspirate again; if the product is clear, inject drug; if blood is still aspirated, abandon the procedure

- *If CSF is encountered*, the procedure can be continued, but inject *slowly*
  - Use half the calculated volume if using xylazine or local anesthetic
  - Normal calculated volume is safe if using narcotics alone
- Wait 10 to 30 minutes for full effect (lidocaine has a faster onset than bupivacaine does)
- Approximate volumes of drug required:
  - Lidocaine 2%, 1 ml/4.5 kg (anesthesia caudal to L1)
  - Lidocaine 2%, 1 ml/6 kg (cesarean section; reduced dose required in pregnancy)
  - Lidocaine 2%, 1 ml/5 kg + 1:200,000 epinephrine (anesthesia caudal to diaphragm)
  - Bupivacaine 0.5%, 1 ml/5 kg + 1:200,000 epinephrine (anesthesia caudal to diaphragm)
  - Preservative-free morphine (Duramorph) 1 mg/ml, 0.1 ml/kg
  - Preservative-free fentanyl 50 mg/ml, 0.1 to 0.2 ml/kg (dogs)

3.9.14 Rabbits

3.9.14.1 General Information Regarding Epidural Blocks in Rabbits

- We do not recommend the use of local anesthetics; because this species relies so heavily on hindlimb function for locomotion, slow return of motor function may cause distress and panic with possible injury
- Systemic absorption of narcotic may occur and may affect gut motility; monitor rabbits after epidural for appetite, attitude, etc.
- Hair regrowth after clipping is unaffected

3.9.14.2 Technique

- Place rabbit in sternal recumbency with hips flexed
- Needle size depends on size of rabbit:
  - Large rabbits, 22-gauge, 2.5-cm needle
  - Small rabbits, 25- to 27-gauge, 1-cm needle

- Use the thumb and second finger of the nondominant hand to feel the iliac crests on either side of the midline
- Keeping these digits in position on these crests, use the index finger of the same hand to feel the depression in the midline just cranial to the first dorsal spinous process of sacrum
- Using the dominant hand, insert the needle into this space perpendicular to the skin surface and exactly in the midline (i.e., not tilting to either side)
- Steadily push the needle in, then inject a small volume of air (e.g., 0.1 ml) to test for lack of resistance to injection
- Check for blood in needle hub, and if none is present slowly inject drug; there should be no resistance to injection
- *If resistance is felt* it usually means that the needle is positioned against bone or has not penetrated the ligament; readjust the position slightly and aspirate before continuing
- *If blood is encountered,* do not inject but withdraw the needle slightly or use a new needle and repeat; if the aspirate is clear, inject drug; if blood is still aspirated, abandon the procedure
- *If CSF is encountered*, the procedure can be continued, but inject *slowly*
  - Use half the calculated volume of narcotic
- Approximate volume of drug required:
  - Preservative-free morphine (Duramorph), 0.35 ml total volume for average adult rabbit of 3.5 kg (this dose is 0.1 to 0.2 mg/kg)

3.9.15 Ferrets

3.9.15.1 Ferret Anatomy

- Ferrets may have five, six, or seven lumbar vertebrae
- Spinal cord ends just before caudal end of last lumbar vertebra

- Dorsal spinous process of last lumbar vertebra may or may not be palpable; height varies among individuals

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- The first of the three dorsal spinous processes of the sacrum can usually be palpated

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3.9.15.2 Technique

- Place ferret in sternal recumbency with hips flexed
- Use the thumb and second finger of the nondominant hand to feel the iliac crests on either side of the midline
- Keeping these digits in position on these crests, use the index finger of the same hand to feel the depression in the midline just cranial to the first dorsal spinous process of sacrum
- Using the dominant hand, insert the needle into this space perpendicular to the skin surface and exactly in the midline (i.e., not tilting to either side)
- Steadily push the needle in, then inject a small volume of air (e.g., 0.1 ml) to test for lack of resistance to injection
- Check for blood in needle hub, and if none is present slowly inject drug; there should be no resistance to injection
- *If resistance is felt* it usually means that the needle is positioned against bone or has not penetrated the ligament; readjust the position slightly and aspirate before continuing
- *If blood is encountered,* do not inject but withdraw the needle slightly or use a new needle and repeat; if aspirate is clear, inject drug; if blood is still aspirated, abandon the procedure
- Approximate volume of drug required:
  - Preservative-free morphine (Duramorph), 0.1 ml total volume for average ferret of 1 kg (this dose is 0.1 mg/kg)

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4 Chapter 4 Electrocardiogram

4.1 HEART RATE CALCULATION

Calculate heart rate from electrocardiogram (ECG) strip as follows.

- Each large box = 5 × 5 small boxes
- At a paper speed of 25 mm/sec:
  - 5 large boxes (a 25-mm length of paper) pass in 1 second
  - In 1 minute, 5 × 60 boxes (300) pass
    - Therefore each large box = 0.2 second
  - 25 small boxes pass in 1 second
  - In 1 minute, 25 × 60 boxes (1500) pass
    - Therefore each small box = 0.04 second

Use either of the following methods to calculate heart rate. (Either method can be used in any species, as long as the heart rhythm is regular; this method is not reliable if bradycardia with pauses is present.)

First, start at a complex on a heavy line (see arrows in figures following), then go to the next complex.

- Count number of large boxes (5 × 5 small boxes) between consecutive R waves of complexes
  - Divide 300 by this number
- Count the number of small boxes between consecutive R waves of complexes
  - Divide 1500 by this number

At a paper speed of 50 mm/sec use the same method but substitute 600 for 300 and 3000 for 1500.

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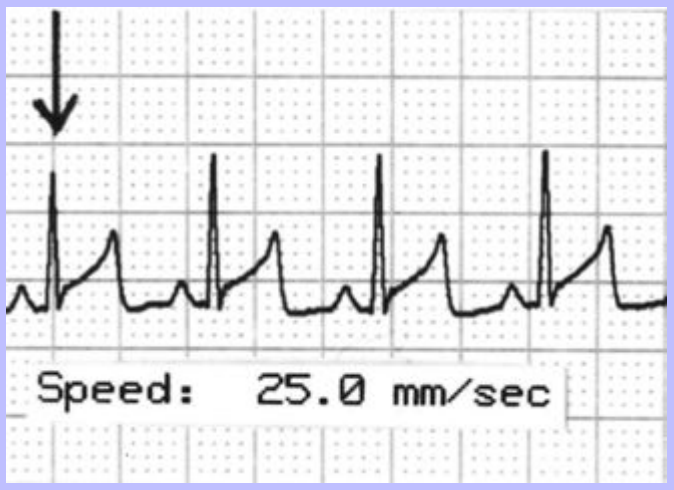
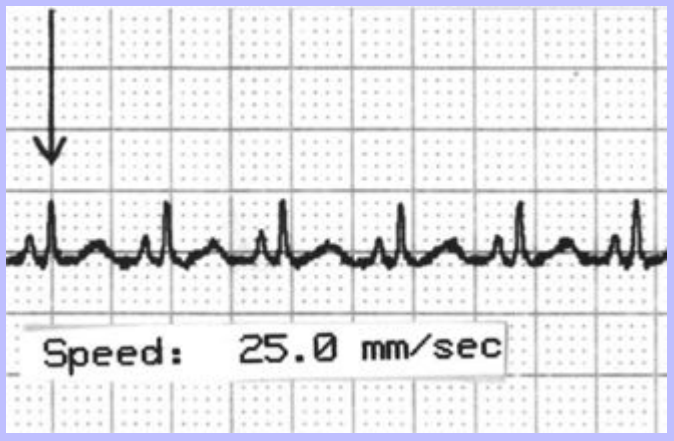
4.1.1 Dog

This dog's heart rate can be calculated as 300 ÷ 2.4 = 125. An alternative method is 1500 ÷ 12 = 125.



4.1.2 Cat

This cat's heart rate can be calculated as 1500 ÷ 9.5 = 158. An alternative method is 300 ÷ 1.9 = 158.



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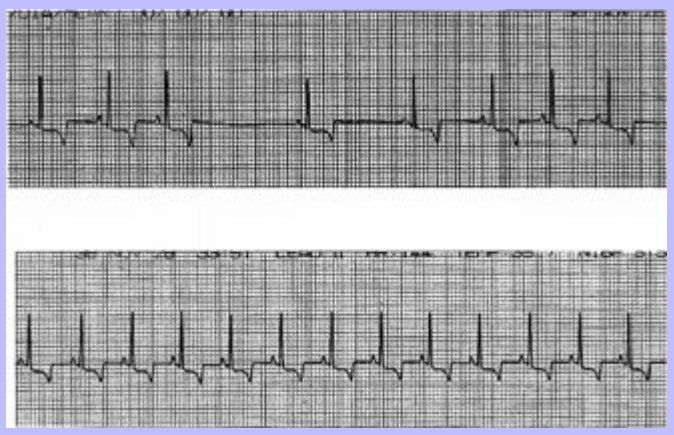
4.2 RESPIRATORY SINUS ARRHYTHMIA

4.2.1 Features

- Alternating periods of faster and slower heart rates, often related to respiratory pattern
- Increased heart rate during inspiration
- Decreased heart rate during expiration and respiratory pause
- Usually, normal conformation of P wave and QRS complexes
- Accentuated with increased vagal tone or vagotonic procedures (e.g., increased ophthalmic pressure)
- May be more noticeable in brachycephalic breeds

Respiratory sinus arrhythmia in upper strip has been replaced by sinus rhythm after administration of anticholinergic agents (*lower strip*).



4.2.2 Therapy

- Normal finding; no therapy usually necessary
- If arrhythmia is pronounced or is associated with marked bradycardia, anticholinergic agents may be administered

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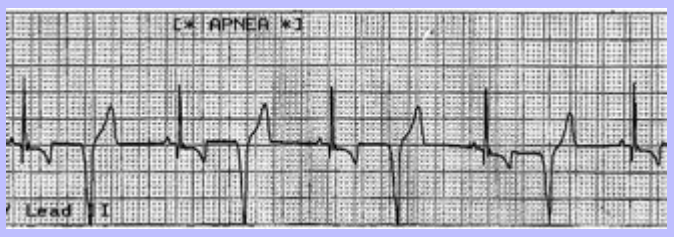
4.3 VENTRICULAR BIGEMINY

4.3.1 Features

- Normal complexes alternate with premature ventricular contractions

Ventricular bigeminy in a dog after thiopental administration for anesthetic induction.



4.3.2 Cause

- Commonly seen after IV barbiturate administration
- Directly related to concentration of solution

4.3.3 Therapy

- Usually not necessary; condition usually resolves within a few minutes; ensure adequate ventilation and evaluate for excessive depth of anesthesia

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4.4 SECOND-DEGREE ATRIOVENTRICULAR BLOCK

4.4.1 Features

- Some P waves not followed by QRS complexes and T waves
- Mobitz type I block
  - PR interval becomes progressively longer until block occurs
  - P waves usually normal
  - QRS and T usually normal when present
- Mobitz type II block
  - PR interval is constant
  - P waves usually normal
  - QRS more often abnormal

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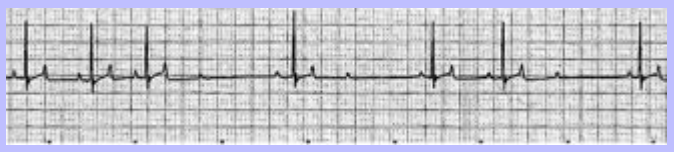
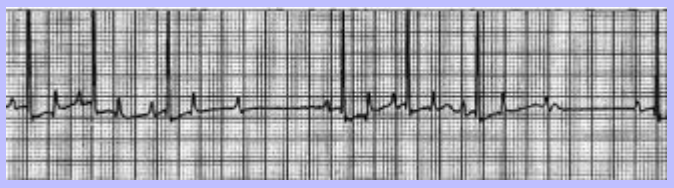
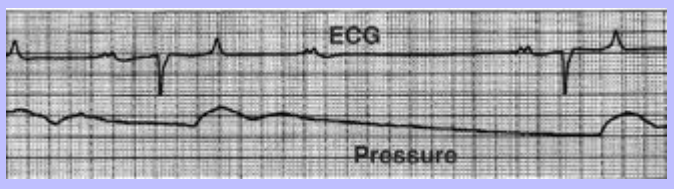
Second-degree atrioventricular block in a dog. This is an example of a type II block (PR interval constant).



Another example of a second-degree atrioventricular block in a dog.



Second-degree atrioventricular block in a horse after xylazine premedication. Note the lack of a pulse wave corresponding to the missing QRS-T complex.



4.4.2 Causes

- Interrupted conduction from atria to ventricles
- Electrolyte imbalances
- Some drugs
  - Xylazine, other alpha$_2$ agonists (common)
  - Low-dose atropine IV
  - Digitalis toxicity
- May occur in young, healthy dogs and horses

4.4.3 Therapy

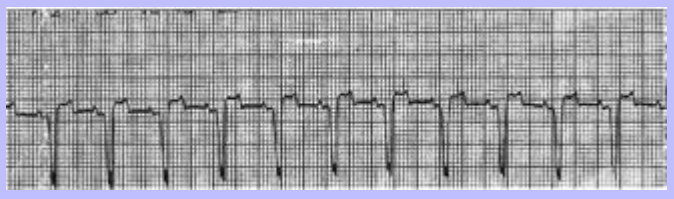
- Not necessary unless rate of normally conducted impulses is very low or if QRS complexes are abnormal
- IV administration of anticholinergic agents
- Stop digitalis if toxicity is the cause
- Cardiac pacing for unresponsive cases (e.g., severe bradycardia that does not respond to anticholinergic agents)

4.5 RIGHT BUNDLE BRANCH BLOCK

4.5.1 Features

- Wide QRS complex
- Normal P waves and consistent relationship between P waves and QRS complexes
- Negative direction
- Deep S wave in lead II

Right bundle branch block in a dog. This was an incidental finding in an apparently healthy anesthetized dog.



4.5.2 Causes

- Delayed or blocked conduction through the right bundle branch
- Cardiac disease or ischemia
- Valvular disease
- Trauma

4.5.3 Therapy

- No specific treatment for the block

- Treat the underlying cause

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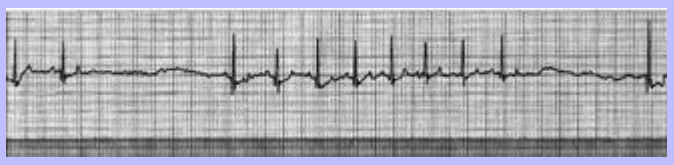
4.6 SINUS ARREST

4.6.1 Features

- Pause in the rhythm longer than two P-P (or R-R) intervals
- Other complexes normal

Sinus arrest in a 6-year-old pug. The pause in the rhythm is longer than two consecutive P-QRS-T complexes in each of two sections of this strip. The coarse baseline is caused by electrical interference, in this case a circulating hot water blanket.



4.6.2 Causes

- No impulse formation in the sinoatrial (SA) node, resulting from:
  - Congenital cardiac defects
  - Cardiac disease (e.g., sick sinus syndrome)
  - Bacterial endocarditis

4.6.3 Therapy

- Not usually necessary if condition occurs infrequently
- Anticholinergic agents may be useful but often are not suitable for long-term therapy
- Pacemaker implantation for long-term control

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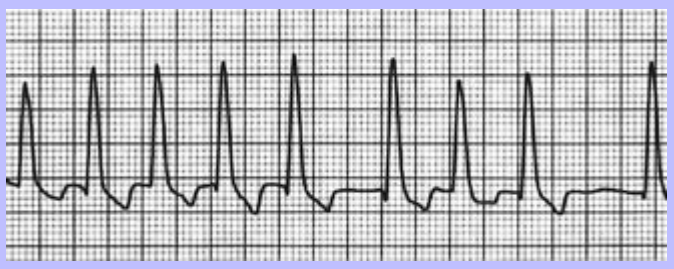
4.7 ATRIAL FIBRILLATION

4.7.1 Features

- Irregular ventricular rhythm

- P waves are replaced by f waves
- f waves may be large (coarse fibrillation) or fine (fine fibrillation)
- QRS complexes may be normal or wide and bizarre

Coarse atrial fibrillation in a dog. (Paper speed 50 mm/sec; 1 cm = 1 mV.) (Courtesy Dr. Don Brown.)



4.7.2 Causes

- Multiple ectopic atrial foci
- Atrial enlargement
- Chronic AV valve insufficiency
- Dilated cardiomyopathy (dogs); congestive heart failure (horses)
- Congenital defects (e.g., patent ductus arteriosus)

4.7.3 Therapy

- No therapy during anesthesia
- Treatment plan after anesthesia includes drugs to slow AV conduction (e.g., digoxin in dogs) or drugs to convert to sinus rhythm (e.g., quinidine in horses)

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4.8 HYPERKALEMIA

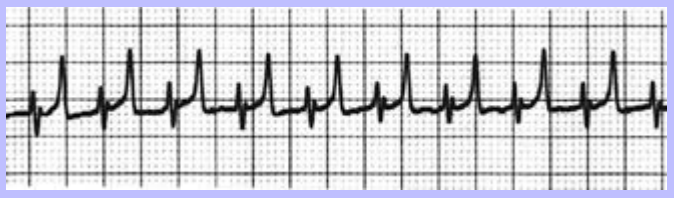
4.8.1 Features

The following sequential changes occur with increasing serum K^+.

- T waves tall and peaked
- Decreased amplitude of R wave; prolonged QRS and PR intervals

- Decreased amplitude of P wave; increased prolongation of QRS and PR intervals
- P wave disappears
- QRS interval widens until a biphasic curve appears
- Condition progresses to ventricular flutter, fibrillation, or asystole

Hyperkalemia in a cat. Missing P waves and tall peakedT waves are characteristic, although bradycardia is a less consistent feature in cats. (Paper speed 25 mm/sec; 1 cm = 1 mV.) (Courtesy Dr. John Rush.)



4.8.2 Causes

- No impulse formation in AV node, associated with the following:
  - Most commonly, urethral obstruction (e.g., cats, goats)
  - Renal insufficiency
  - Diabetic ketoacidosis
  - Addison's disease
  - Excessive K^+ administration

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4.8.3 Therapy

- Immediate therapy required to stabilize the patient
- If surgery is required, stabilize *before anesthesia*
- Reduce serum K^+ (e.g., regular insulin with dextrose, bicarbonate, calcium gluconate, glucocorticoids for Addison's disease)
- Begin fluid therapy once the obstruction has been relieved

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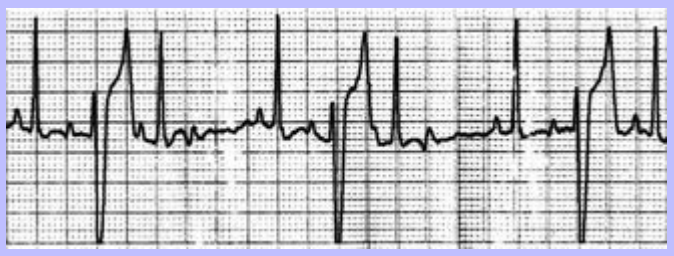
4.9 PREMATURE VENTRICULAR CONTRACTIONS

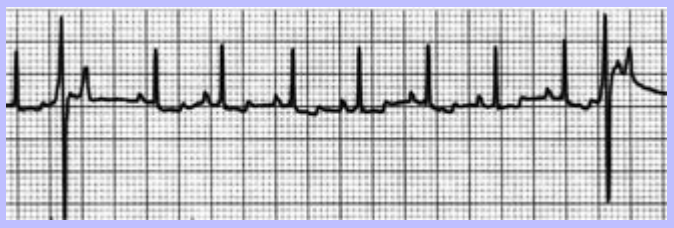
4.9.1 Features

- Normal rhythm interrupted by one or more QRS complexes that are wide, large in amplitude, and bizarre
- Not associated with the P wave
- T wave is in opposite direction to QRS
- Compensatory pause usually follows the premature ventricular contraction (PVC)
- Unifocal if identically shaped; multifocal if different shapes

Premature ventricular contractions (PVCs) in a dog. This is an example of trigeminy with a fixed ratio of 2:1, that is, two normal complexes followed by one PVC. The PVCs are unifocal. (Paper speed 25 mm/sec; 1 cm = 1 mV.) (Courtesy Dr. Don Brown.)



Another example of unifocal premature ventricular contractions in a dog. (Paper speed 25 mm/sec; 1 cm = 1 mV.) (Courtesy Dr. Don Brown.)



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4.9.2 Causes

- Many potential causes, both cardiac and noncardiac
- Examples include congestive heart failure, myocarditis, gastric dilation and volvulus, pancreatitis, uremia, atropine use

4.9.3 Therapy

- Treat the underlying problem first
  - Ventilate or oxygenate
  - Lighten the depth of anesthesia
  - Correct electrolyte or acid-base imbalance, anemia
- Treat with lidocaine IV if:
  - Condition progresses to ventricular tachycardia
  - QRS complexes are multiform (variable shapes)
  - R wave of PVC falls on T wave of preceding complex
- Treat with lidocaine IV as a bolus and continue as an infusion if PVCs reappear
  - Bolus at 2 to 4 mg/kg IV
  - Infusion at 40 to 75 µg/kg/min
- Cats are sensitive to lidocaine toxicity and the dose for cats should be one tenth to one quarter of this dose

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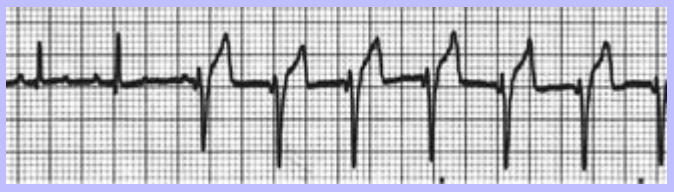
4.10 VENTRICULAR TACHYCARDIA

4.10.1 Features

- QRS complexes are wide, large in amplitude, and bizarre
- No relationship to P waves

Ventricular tachycardia in a dog. (Paper speed 25 mm/sec; 1 cm = 1 mV.)



4.10.2 Causes

- Cardiac disease

- Myocardial ischemic event
  - Gastric dilation and volvulus
  - Trauma
  - Endotoxemia, pyometra, etc.

4.10.3 Therapy

- Lidocaine IV administered as a bolus and continued as an infusion
  - Bolus at 2 to 4 mg/kg IV
  - Infusion at 40 to 75 µg/kg/min
- Cats are sensitive to lidocaine toxicity and the dose for cats should be one tenth to one quarter of this dose
- Treat any underlying condition such as acid-base or electrolyte abnormalities

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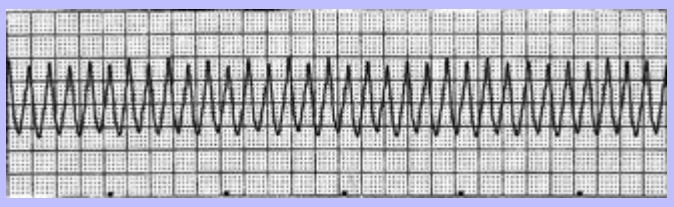
4.10.4 Sustained Ventricular Tachycardia (Greater than 30 Seconds' Duration)

An extreme example of ventricular tachycardia in a dog with severe cardiac disease. (Paper speed 25 mm/sec; 1 cm = 1 mV.)



4.10.5 Causes

- Often caused by primary cardiac disease

4.10.6 Therapy

- Lidocaine IV administered as a bolus and continued as an infusion
  - Bolus at 2 to 4 mg/kg IV
  - Infusion at 40 to 75 µg/kg/min
- Treat any underlying condition such as acid-base or electrolyte abnormalities

- Electrical cardioversion if no change occurs after other treatments

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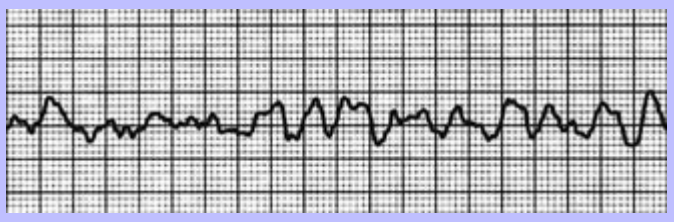
4.11 VENTRICULAR FIBRILLATION

4.11.1 Features

- Waves are irregular and bizarre
- May be coarse or fine
- Usual components of the P-QRS-T complexes are not recognizable
- Causes cardiac arrest and must be treated immediately

Coarse ventricular fibrillation in a dog. (Paper speed 25 mm/sec; 1 cm = 1 mV.) (Courtesy Dr. Don Brown.)



4.11.2 Causes

- Trauma
- Myocardial disease
- Severe electrolyte and acid-base imbalances, particularly potassium or calcium
- Anesthetic overdose
- Direct cardiac manipulation during surgery
- Catecholamine administration (e.g., excessive use during inhalant anesthesia for hemostasis)

4.11.3 Therapy

- Rapidly defibrillate (2-4 Joule/kg external; 0.2-0.4 Joule/kg internal)
- Must treat immediately with “A-B-C-D-E-F” of cardiopulmonary resuscitation
- Treat underlying causes (e.g., acid-base or electrolyte imbalance) immediately if patient is resuscitated
- Lidocaine is unlikely to improve ventricular fibrillation and increases the energy required to defibrillate

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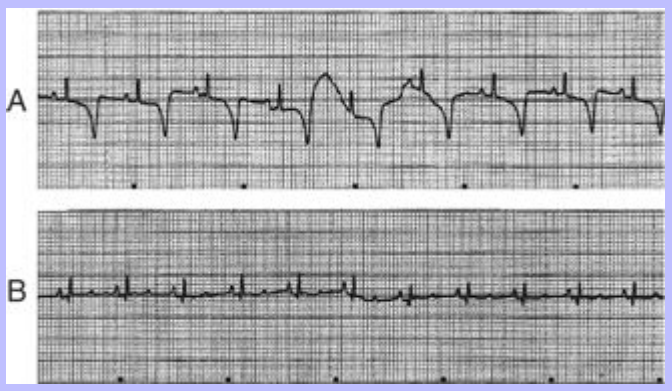
4.12 MISCELLANEOUS CONDITION

This strip was from a dog undergoing surgery for removal of a large abdominal mass. Electrolytes, acid-base status, and oxygenation were normal at the time of this recording.

A, T wave is abnormally wide and large in amplitude. The bizarre-looking complexes (fifth and sixth from the left) are caused by movement of the body during manipulation by the surgeon. **B,** ECG printed immediately after the large mass was lifted from the abdominal cavity, with no adjustments made to the recording apparatus.



4.12.1 Cause

- The most likely cause of the abnormal upper strip was pressure exerted by the mass on the abdominal vena cava, which caused an impairment of venous return and some degree of myocardial hypoxia.

5 Chapter 5 Fluids

5.1 ACUTE CHANGES IN $Paco_2$

$Paco_2$ refers to partial pressure (P) of arterial (a) carbon dioxide (CO_2). (An *A* used in this term would denote alveolar carbon dioxide.)

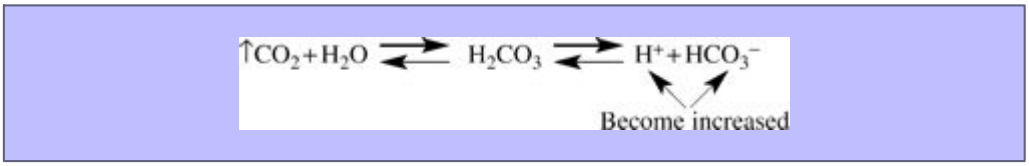
CO_2 is produced by cellular metabolism and is not normally present in anesthetic gases.

In room air CO_2 is negligible, constituting approximately 0.03%.

5.1.1 In Body Fluids

$$CO_2 + H_2O \rightleftharpoons H_2CO_3 \rightleftharpoons H^+ + HCO_3^-$$

- Units of measurement:
  - CO_2 is measured as gaseous partial pressure, mm Hg ($Paco_2$)
  - H^+ is measured as units, the negative log of ionic concentration in moles/L (pH)
  - HCO_3^- is measured as ionic concentration, mEq/L (HCO_3^-)
- Average values in arterial blood in a normal, healthy, conscious animal at rest:
  - $Paco_2$ = 40 mm Hg
  - pH = 7.4
  - HCO_3^- = 24 mEq/L
- *Increased CO_2* causes increased production of H^+ (lowers the pH value) and HCO_3^-

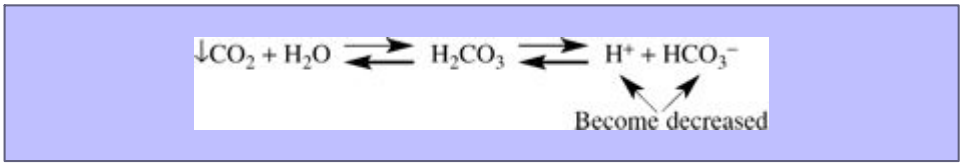


- *During anesthesia*, increased CO_2 is caused by:
  - Inadequate ventilation
    - Deep anesthesia
    - Inappropriate ventilator settings

- Effects of some drugs
- Pulmonary disease

- CO_2 administration to the patient
  - Absorbent is exhausted and is not removing CO_2 from expired gas
  - One-way valve is malfunctioning; expired gas is reaching patient
- Increased cellular production
  - Malignant hyperthermia (rare)
  - High fever

- *Decreased CO_2* reduces the concentrations of H^+ (increases the pH value) and HCO_3^-



- *During anesthesia*, decreased $PaCO_2$ is caused by:
  - Excessive ventilation
    - Inappropriate ventilator settings
    - Excessive manual ventilation while practitioner checks several times for seal on endotracheal tube cuff

Table 5-1 lists guidelines for values expected with acute changes in $PaCO_2$. Actual changes in pH with changes in CO_2 are not quite as large as shown in the table, but this is easy to remember, and the changes shown are relatively close to the true changes.

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Table 5-1 Values Expected with Acute Changes in $PaCO_2$

CO_2	pH	HCO_3^-
100	7.1	30
80	7.2	28
60	7.3	26
40	7.4	24
30	7.5	22
20	7.6	20
10	7.7	18

Shaded area indicates normal value. Note that increased $PaCO_2$ causes acidosis but also causes an increase in HCO_3^-.

Do not treat pure respiratory acidosis with bicarbonate.

Treat the primary disorder by improving ventilation.

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5.2 ADDING DEXTROSE TO FLUIDS

- Based on using 50% dextrose but applicable to other concentrations
- Refrigerate 50% dextrose once opened
- Use the dextrose-fluids solution immediately after formulation
- An isotonic solution becomes hypertonic when dextrose is added
- Do not use IV in a dehydrated animal

5.2.1 How to Calculate How Much 50% Dextrose to Add to Fluid Bag

- What percentage of dextrose is required in the IV fluids to be administered?
- How many milliliters of fluid are currently in the bag?

$$\left\{\frac{\text{Percentage of dextrose required} \times \text{fluid in bag (ml)}}{\text{Percentage of dextrose used}}\right\} = \text{Dextrose to add (ml)}$$

5.2.1.1 Examples

- Requirement is 2.5% dextrose in a 500-ml bag of lactated Ringer's solution (LRS)

$$\left\{\frac{2.5 \times 500}{50}\right\} = \text{? ml of 50\% dextrose to add}$$
$$= 25 \text{ ml}$$

- Requirement is 5% dextrose in a bag that has 350 ml of LRS remaining

$$\left\{\frac{5 \times 350}{50}\right\} = \text{? ml of 50\% dextrose to add}$$
$$= 35 \text{ ml}$$

- Requirement is 2.5% dextrose in a 20-ml syringe of LRS for a tiny patient (e.g., a kitten)

$$\left\{\frac{2.5 \times 20}{50}\right\} = \text{? ml of 50\% dextrose to add}$$
$$= 1 \text{ ml}$$

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- For greater accuracy but little clinical importance, first remove from the fluids the volume that corresponds to the volume of dextrose to be added
  - In example 1 above, remove 25 ml of LRS and then add 25 ml of 50% dextrose
  - In example 2, remove 35 ml of LRS and then add 35 ml of 50% dextrose

- In example 3, add 1 ml of 50% dextrose to 19 ml of LRS (for example 3, if 1 ml is added to 20 ml to make 21 ml, the final concentration will be 2.38% instead of 2.5%)

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5.3 COMPOSITION OF PARENTERAL FLUIDS

Solution	Na^+ (mEq/L)	K^+ (mEq/L)	Ca^{++} (mEq/L)	Mg^{++} (mEq/L)	Cl^- (mEq/L)	Glucose (mmole/L)	Lactate (mmole/L)	Acetate (mmole/L)	pH	Osmolality (mOsm/L)	Calories (kcal/L)
Extracellular fluid*	142	4	5	3	103	—	—	—	7.4	280	—
Lactated Ringer's	130	4	2.7	—	109	—	28	—	6.5	273	—
0.45% NaCl	77	—	—	—	77	—	—	—		155	—
0.9% NaCl	154	—	—	—	154	—	—	—	5	308	—
2.5% Dextrose in water	—	—	—	—	—	25	—	—	—	126	85
5% Dextrose in water	—	—	—	—	—	50	—	—	4	252	170
2.5% Dextrose in 0.45% NaCl	77	77	—	—	—	25	—	—	4.5	280	85
5% Dextrose in 0.45% NaCl	77	77	—	—	—	50	—	—	—	405	170
5% Dextrose in 0.9% NaCl	154	154	—	—	—	100	—	—	—	560	170
2.5% Dextrose in ½ LRS	65.5	2	1.4	—	54	138	14	—	6	265	[illegible]
5% Dextrose in LRS	130	4	2.7	—	109	50	28	—	5	525	179
Plasmalyte 56	40	13	—	3	40	—	—	16	5.5	111	—
Plasmalyte R	140	10	5	3	103	—	8	47	—	312	—
Plasmalyte A	140	5	—	3	98	23	—	27	7.4	294	—

* Extracellular fluid values are average for most species.

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5.4 FLUID ADMINISTRATION RATE

5.4.1 General Formula for Routine Fluids during Surgery

10 ml/kg/hr

Body weight in kilograms × 10 = Number of milliliters per hour = Number of milliliters per 3600 seconds

$$\left\{\frac{\text{Body weight in kilograms} \times 10}{3600}\right\} = \text{Number of milliliters per second}$$

5.4.2 How Many Drops in a Milliliter?

- Depends on the IV set
- Adult (white) = 10 drops/ml or 15 drops/ml (check the packaging instructions)
- Pediatric (blue) = 60 drops/ml

5.4.3 Calculation of Drops per Second

10 drops/ml	$\frac{kg \times 10 \times 10}{3600}$	kg ÷ 36 = drops/sec
15 drops/ml	$\frac{kg \times 10 \times 15}{3600}$	kg ÷ 24 = drops/sec
60 drops/ml	$\frac{kg \times 10 \times 60}{3600}$	kg ÷ 6 = drops/sec

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5.5 MILLIMOLES, MILLIEQUIVALENTS, AND MILLIOSMOLES

5.5.1 Millimole

- 1 mole (mol) = atomic or molecular weight in grams
- 1 millimole (mmol) is 0.001 mole

5.5.1.1 Examples

- *Glucose* has a molecular weight of 180
  - 1 mol of glucose = 180 g
  - 1 mmol of glucose = 180 mg
  - 1 mmol/L = 180 mg of glucose in 1L
    - More commonly measured as 18 mg/dl
- *Sodium ion* (Na^+) has an atomic weight of 23
  - 1 mol of Na^+ = 23 g
  - 1 mmol of sodium ions = 23 mg
  - 1 mmol/L = 23 mg of Na^+ in 1L

Millimoles per Liter = Molarity

One mole of any substance that does not dissociate contains approximately 6.02×10^{23} particles.

- For example, 1 mole of Na^+, 1 mole of glucose, and1 mole of calcium ions (Ca^{++}) all contain approximately 6.02×10^{23} particles, regardless of the atomic or molecular weight of the substance

5.5.2 Milliequivalent (mEq)

- One electrochemical equivalent (Eq) = the quantity of ion that combines with or displaces one hydrogen ion (H^+), measured in grams
- 1 mEq = 0.001 Eq
- This is the usual way to measure ions in the body, because they are present in relatively small quantities

5.5.2.1 Examples

- Glucose does not have an electrochemical equivalent because it does not dissociate into ions

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- Sodium ion (Na^+) cannot combine with H^+ directly, but it can combine with an ion that has one negative charge (e.g., chloride ion [Cl^-])
  - This is equivalent to displacing one H^+ ion, which means that Na^+ has an equivalence of one
- Calcium ion (Ca^{++}) can combine with two negative ions (e.g., two Cl^- ions), and so has an equivalence of two

Ionic charge on an ion = Valence

For ions, millimoles per liter × ionic charge (valence) = milliequivalents per liter

5.5.3 Milliosmoles (mOsm)

- Bodily fluids contain various solutes such as ions, glucose, proteins, urea, etc.
- Cells containing these solutions are separated from one another by semipermeable membranes
- Changes in concentration of any solute within a cell can occur by movement of either the solute or water
- Solute movement depends on the permeability of the cell membrane to the solute
  - Urea and gases are lipid soluble and can diffuse directly through the membrane
  - Water-soluble substances (ions, glucose) move through pores in the membrane
- Movement occurs passively or actively
  - Passive movement
    - Diffusion caused by electrochemical forces (applies only to charged particles)

- Ions tend to move toward the side of the membrane that has the opposite charge

- Diffusion caused by a concentration gradient
  - Movement of solute occurs from an area of high concentration to one with a lower concentration

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  - If solute cannot cross the membrane, water can move into the area with the higher concentration of solute

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- Diffusion of water across a membrane into an area with a higher concentration of solutes creates increased hydrostatic pressure on the side of the membrane that gains the water
- Eventually the hydrostatic pressure on the side that gains the water is sufficient to oppose the forces pulling water in, and further water movement is prevented
- This pressure at equilibrium is the *osmotic pressure*
- Osmotic pressure is proportional to the number of particles of solute per unit volume of solvent, measured as osmoles (osm) per unit volume of solvent
  - 1 osm = 1 mol (gram molecular weight) of any solute that does not dissociate
  - 1 osm = 6.02×10^{23} particles, regardless of their size, valence, or weight
  - 1 mOsm = 0.001 osm

Osmolality = osmoles per kilogram of water
Osmolarity = osmoles per liter of water (osmo*larity—liter)*

□ Active movement

- Energy is used to move solutes against a concentration or electrochemical gradient
- For example, the Na^+-K^+-ATPase pump in the cell membrane (ATP, adenosine triphosphate) moves Na^+ out of the cell and K^+ into the cell

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5.5.4 Relationship among Units of Measure for Some Solutes in Bodily Fluids

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Solute	Atomic or Molecular Weight (mg)	mmole	mEq	mOsm
Na^+	23	1	1	1
K^+	39.1	1	1	1
Ca^{++}	40	1	2	1
Mg^{++}	24.3	1	2	1
Cl^-	35.5	1	1	1
Glucose	180	1	—	1

5.5.5 Osmolality Range

Osmolality range of normal extracellular fluid (ECF) and relative position of various crystalloid solutions is shown in the figure on the next page. The number immediately under each solution is the osmolality of that solution. Normal osmolality of ECF is 285 to 300. In the figure Pls stands for Plasmalyte.

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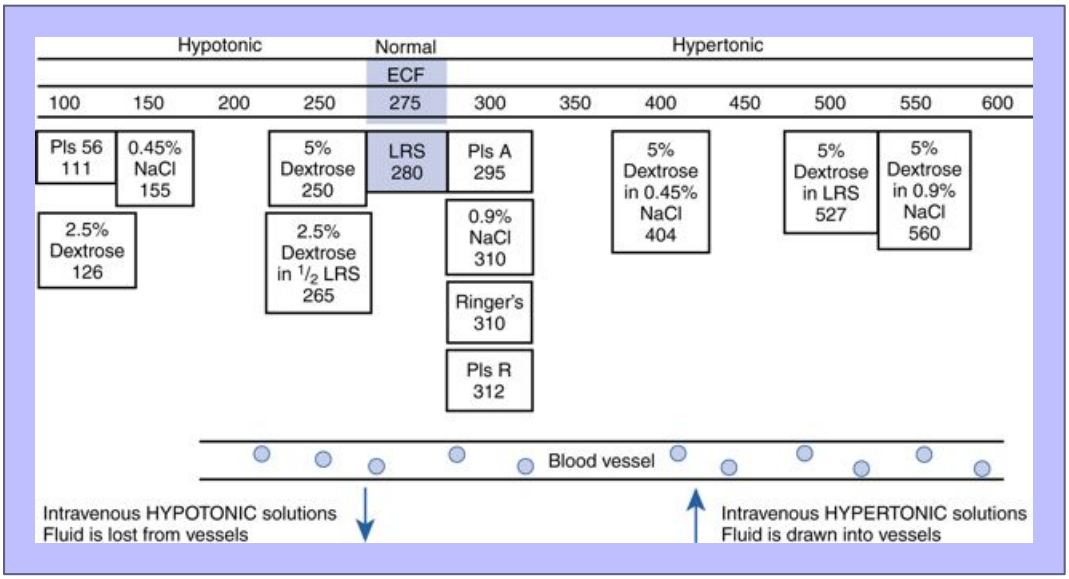

6 Chapter 6 Blood and Blood Substitutes

6.1 BLOOD

6.1.1 Features and General Information

- Best replacement for lost whole blood; component therapy widely available
- More appropriate to use packed red cells in patients with anemia and normal total protein and blood volume to avoid circulatory overload from colloids in whole blood
- May be difficult to obtain whole blood in emergency situations
- Decision to transfuse in surgery depends on hematocrit, rate of loss, and other factors; generally, transfuse if:
  - Hematocrit is approaching 20%
  - Tachycardia or hypotension occurs without other obvious cause
  - More than 15% to 20% of blood volume is lost acutely from an animal with an initially normal hematocrit
- Blood administration set is used for transfusion; contains a filter not found in regular IV administration sets
- May be administered as IV bolus in crisis situation
- To flush a blood line, use only 0.9% NaCl; coagulation is activated by any solution that contains calcium (e.g., lactated Ringer's solution [LRS], Plasmalyte)
- Warm the blood to 37° C before transfusion; higher temperature causes loss of protein and hemolysis
- Blood typing should be performed
- Cross-match is ideal (see discussion later in this chapter) for dogs that have previously undergone transfusion or have had puppies

- Ferrets have no detectable blood groups (all are universal donors)
- Blood volume is approximately 7% of body weight, but some variation exists among species

6.1.2 Blood Volume and Blood Groups in Various Species

Species	Blood (ml) per Kilogram of Body Weight	Number of Blood Group Systems	Blood Group Systems
Horses*	70–100	7	A, C, D, K, P, Q, U
Cattle	57–60	11	A, B, C, F, J, L, M, R, S, T, Z
Sheep	60–70	6	A, B, C, D, M, R
Goats	60–70	5	A, B, C, M, J
Pigs	50–70	16	A, B, C, D, E, F, G, H, I, J, K, L, M, N, O, P
Dogs*	75–90	>11	DEA 1.1, 1.2, 3, 4, 5, 6, 7, 8
Cats	45–65	3	AB (A, B, and AB)
Rabbits	55–70	NRP	—
Ferrets	53–60	None detectable	—

NRP, Not reported.

* These species can mobilize splenic reserves of blood more readily than other species can.

6.1.3 Cross-Matching

- Tests recipient's plasma with donor's washed cells (major cross-match) or donor's plasma with recipient's washed cells (minor cross-match)
- Determines whether saline agglutinating-type antibodies are present in donor or recipient sera
- Cats should always be typed, even for plasma transfusions, because of naturally occurring alloantibodies
- Dogs should be cross-matched if they have previously undergone transfusion or had litters; cross-matching not necessary otherwise

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6.1.3.1 Cross-Matching Technique

6.1.3.1.1 Simple technique

- Add one drop of recipient blood to one drop of donor blood on glass slide
- Agglutination indicates that donor and recipient are incompatible

6.1.3.1.2 Other technique

- Collect recipient blood in EDTA tube
- Centrifuge and collect plasma
- Collect donor cells; wash four times with 0.9% NaCl
- Resuspend cells to 4% to 6% in 0.9% NaCl
- Add one drop of donor cells to two drops of recipient plasma

- Incubate at 37° C for 15 minutes
- Centrifuge for 15 seconds at approximately 3500 rpm
- Resuspend tube and check for agglutination grossly and under microscope

6.1.3.2 Amount of Donor Blood Needed

- In general, 2.2 ml/kg of whole blood (packed cell volume [PCV] 40%) increases PCV by 1%, if active bleeding is not occurring
- In anesthesia, transfuse until perfusion improves to a degree judged acceptable according to clinical parameters

6.1.4 Rate of Administration

- Administer 0.5 ml/kg IV during first half hour while monitoring for adverse reaction
- Administer 10 ml/kg IV for remainder of transfusion

6.1.5 Transfusion Reaction

- Hypotension and tachycardia (may already be present because of blood loss)
- Hyperthermia
- Cutaneous wheals, especially in dogs
- Peripheral edema
- Pulmonary edema
- Pruritus (in awake patient)

- Petechial hemorrhage (may be difficult to appreciate in anesthetized patient)

6.1.5.1 Treatment of Transfusion Reaction

- Stop transfusion
- Lighten or discontinue anesthesia
- Administer diphenhydramine 1 mg/kg IM
- Monitor temperature
- Provide general support
  - Administer oxygen

- Administer fluids
- Monitor for hemoglobinuria

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6.2 DEXTRAN

6.2.1 Features and General Information

- Synthetic polysaccharides of varying molecular weights
- Used to support circulation by increasing colloid osmotic pressure (e.g., in patients with low total protein)
- No ability to carry oxygen
- Average molecular weights:
  - Dextran 40 = 40,000
  - Dextran 70 = 70,000
  - Dextran 75 = 75,000
- Vascular expansion has relatively short duration (2 to 3 hours for dextran 40; up to 6 hours for dextran 70)
- Usually is administered via large syringe for more control of volume used; should be injected slowly
- Rapid administration may be necessary in crisis situation
- Use equal volume of crystalloids (e.g., LRS) with dextran 40 to reduce oncotic effect and resultant rapid fluid shift from intracellular space
- Eliminated by glomerular filtration and renal excretion (smaller molecules) or metabolism in reticuloendothelial system (larger molecules)
- May not be suitable in large animal species because of cost
- No special storage requirements; room temperature is suitable

6.2.2 Rate of Administration

- 10 to 20 ml/kg IV
- Administer slowly while monitoring hemodynamics carefully

6.2.3 Total Volume to Use

- Based on hemodynamic response

- The following should be adhered to because of the long-lasting effect:
  - Dogs: 20 ml/kg/day

  - Cats: 10 ml/kg/day
  - Ferrets: not reported, but we suggest 10 ml/kg/day

6.2.4 Adverse Reactions

- Allergic reaction
- Coagulopathy, especially with rapid administration
- Pulmonary edema may occur with excess administration

6.2.4.1 Treatment of Allergic Transfusion Reaction

- Stop transfusion
- Lighten or discontinue anesthesia
- Administer diphenhydramine 1 mg/kg IM
- Monitor temperature
- Provide general support
  - Administer oxygen
  - Administer fluids
  - Monitor for hemoglobinuria

6.3 HETASTARCH

6.3.1 Features and General Information

- Synthetic polysaccharide, mainly starch molecules of varying molecular weight
- Hydroxyethyl groups added to retard degradation
- Used to support circulation by increasing colloid osmotic pressure (e.g., in patients with low total protein)
- Colloidal effects similar to those of albumin (average molecular weight of both is 69,000)
- No ability to carry oxygen
- Usually is administered via large syringe for more control of volume used; should be injected slowly

- Eliminated by glomerular filtration and renal excretion (smaller molecules) or slowly degraded by amylase (larger molecules)
- Vascular expansion is long lasting (up to 24 hours)
- May not be suitable for use in large animal species because of cost
- No special storage requirements; room temperature is suitable

6.3.2 Rate of Administration

- Administer slowly while monitoring hemodynamics carefully

6.3.3 Total Volume to Use

- Based on hemodynamic response
- The following should be adhered to because of the long-lasting effect:
  - Dogs: 20 ml/kg/day
  - Cats: 10 ml/kg/day
  - Ferrets: not reported, but we suggest 10 ml/kg/day

6.3.4 Adverse Reactions

- Allergic reaction
- Coagulopathy
- Volume overload, especially in cats; do not use in cats or dogs with cardiac disease or renal failure

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6.3.4.1 Treatment of Allergic Transfusion Reaction

- Stop transfusion
- Lighten or discontinue anesthesia
- Administer diphenhydramine 1 mg/kg IM
- Monitor temperature
- Provide general support
  - Administer oxygen
  - Administer fluids

- Monitor for hemoglobinuria

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6.4 HYPERTONIC SALINE

6.4.1 Features and General Information

- Used in severe shock, especially hemorrhagic
- Do not use for routine circulatory support
- Causes rapid response
- Improves plasma volume, cardiac output, blood pressure, and tissue perfusion
- Causes shift of water out of extracellular fluid space into vascular space, hence shift out of intracellular compartment into extracellular compartment
- Eventual total body water deficit occurs (after natriuresis)
- Vascular expansion has short duration (1 to 3 hours)
- Can add to dextran 70 for more prolonged effect
- Commercially available as 3%, 5%, or 7.2%
- Small volume required; therefore fluid overload unlikely

6.4.2 Total Volume to Use

- Horses: 4 to 8 ml/kg IV
- Dogs, cats: 2 to 8 ml/kg IV
- Assess hemodynamic response to low dose to assess optimal volume to use

6.4.3 Rate of Administration

- 1 ml/kg/min

6.4.4 Adverse Effects

- Hypernatremia
- Hyperchloremia
- Do not use in patients with renal insufficiency

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6.5 OXYGLOBIN

6.5.1 Features and General Information

- Oxygen-carrying solution made from purified hemoglobin of bovine origin in a modified LRS
- Used in situations in which whole blood or packed red cells are required but are unavailable
- Especially useful in ferrets because donor blood is so rarely available
- Use a normal IV administration set or large syringe
- Can use an IV bolus in crisis situation
- Not suitable for use in large animal species because of cost
- No special storage requirements; room temperature is suitable
- Hemoglobin, not hematocrit, must be measured to assess response
- Hemoglobin concentration of Oxyglobin is 13 g/dl
- Serum may be hemolyzed

6.5.2 Rate of Administration

- Dogs: 10 ml/kg/hr
- Cats: 5 ml/kg/hr
- Ferrets: not reported, but we use 5 ml/kg/hr

6.5.3 Total Volume to Use

- Dogs: 15 to 30 ml/kg
- Cats: 10 ml/kg
- Ferrets: not reported, but we use 10 ml/kg

6.5.4 Adverse Reactions

- Pulmonary hypertension; do not use in patients with pulmonary problems
- Volume overload, especially in cats; do not use in cats or dogs with cardiac disease or low output renal failure
- Allergic reaction

- Some blood chemistry tests are affected by discolored plasma
- Temporary discoloration of sclera, urine, and mucous membranes

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6.5.4.1 Treatment of Transfusion Reaction

- Stop transfusion
- Lighten or discontinue anesthesia
- Administer diphenhydramine 1 mg/kg IM
- Monitor temperature
- Provide general support
  - Administer oxygen
  - Administer fluids
  - Monitor for hemoglobinuria

6.6 SUGGESTED READINGS

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7 Chapter 7 Case Management

7.1 CANINE “HIT-BY-CAR” LIMB FRACTURE

Patients that have been hit by a car may have damage not externally visible. Rule out pneumothorax, bladder rupture, head trauma, and myocardial injury before administration of anesthesia.

7.1.1 Preanesthesia

- With regard to blood work, at a minimum, packed cell volume (PCV), total protein (TP), blood glucose, and blood urea nitrogen (BUN) should be measured
- Anemia secondary to hemorrhage must be corrected before anesthesia; any patient with PCV < 20% should receive blood transfusion
- Perform electrocardiography (ECG); any bodily trauma may produce myocardial injury and result in traumatic myocarditis that manifests as ventricular arrhythmias (premature ventricular contractions or ventricular tachycardia)
- Examine chest radiograph for signs of pneumothorax or pulmonary damage
- An intravenous (IV) catheter is placed for the administration of anesthetic agents and resuscitation fluids; patients in shock are administered “shock-dose” fluids at 90 ml/kg IV; in addition, hypertonic saline or colloids may be administered

7.1.1.1 Premedication

7.1.1.1.1 Agents (mg/kg IM; use half if administering IV)

Oxymorphone* 0.03-0.08 + midazolam (or diazepam)† 0.1-0.3 ± glycopyrrolate 0.01

Morphine* 0.4-0.8 + midazolam (or diazepam)† 0.1-0.3 ± glycopyrrolate 0.01

Buprenorphine 0.01-0.02 + midazolam (or diazepam)† 0.1-0.3 ± glycopyrrolate 0.01

* Mu-opiate and benzodiazepine administration may lead to hypoventilation; use with caution in patients with respiratory trauma or pneumothorax.

† Acepromazine (0.02-0.05) can be substituted as a sedative only if patient is well hydrated, as vasodilation and hypotension may result.

7.1.2 Induction

- Propofol may induce respiratory depression; use with caution in patients with respiratory trauma; give half the calculated induction dose over 60 seconds; preoxygenate (with oxygen administered via face mask for 5 minutes) before induction to prevent hypoxemia

- Thiopental may exacerbate cardiac arrhythmias and induce ventricular arrhythmias
- Ketamine and benzodiazepine induction may lead to tachycardia or arrhythmias and should be avoided in patients with cardiac trauma; use is recommended in patients with respiratory disease or with pneumothorax, as ventilation is minimally depressed
- Opiate and benzodiazepine induction may lead to hypoventilation or apnea; use with caution in patients with respiratory trauma; bradycardia may result and can be prevented or treated with anticholinergic agents
- Inhalant induction by face mask is acceptable only if patient is not vomiting and pneumothorax is not present

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7.1.2.1 Induction

7.1.2.1.1 Agents (mg/kg IV); give only until effective

Propofol 4-6 (use caution if hypovolemia or hypotension is present)

Thiopental 10 (watch for ventricular arrhythmias)

Ketamine 5 + diazepam (or midazolam) 0.25 (watch for arrhythmias)

Oxymorphone (or hydromorphone) 0.1 + diazepam 0.2

Mask with isoflurane or sevoflurane

7.1.3 Analgesia

- Brachial plexus block if fracture is present in forelimb
- Epidural administration if fracture present in forelimb or hindlimb; if performed before surgery, decreases inhalant requirement during surgery and provides postoperative analgesia for up to 24 hours (if preservative-free morphine is used)
- Fentanyl patch placement before surgery (blood levels of fentanyl and therefore analgesia are not present for 8 to 12 hours after placement; provides only postoperative analgesia)
- Constant-rate infusion of analgesic agent during surgery

7.1.3.1 Constant-Rate Infusion

Agent	Loading Dose (mg/kg IV)	Infusion Rate (µg/kg/hr IV)	Isoflurane MAC Reduction (%)
Fentanyl*	0.01–0.05†	1–5	20–54
Morphine*	0.5–1†	100–150	30–50
Ketamine	0.2–0.5	100–300	20–73
Lidocaine	1–2	50–200	20–40

MAC, Minimum alveolar concentration.

* Opiates are profound respiratory depressants and may necessitate mechanical ventilation of patient during infusion. Not recommended in patients with pneumothorax.

† Bradycardia may result and can be prevented by administration of atropine (0.02 mg/kg IV) or glycopyrrolate (0.01 mg/kg IV) before loading dose.

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7.1.4 Maintenance

- The most rapidly acting, minimally metabolized inhalant agents are preferred
- Isoflurane and sevoflurane are preferred over halothane; halothane sensitizes myocardium to catecholamine-induced arrhythmias (exercise caution in patients with traumatic myocarditis)
- IV fluids must be administered during anesthesia at a rate of 10 ml/kg/hr

7.1.5 Monitoring

- ECG: watch for arrhythmias (particularly ventricular premature contractions [PVCs] and ventricular tachycardia)
  - Prevent bradycardia (heart rate [HR] < 60 beats per minute [bpm])
    - Treat bradycardia with atropine 0.01 mg/kg IM or IV
  - Prevent tachycardia (HR > 200 bpm)
    - Consider source of tachycardia
    - Treat pain with analgesic (e.g., oxymorphone 0.05 mg/kg IM or IV)
    - Ensure adequate anesthetic depth
    - Evaluate blood pressure (hypotension can result in reflex tachycardia)
- Blood pressure should be monitored; mean arterial pressure (MAP) should be maintained above 60 mm Hg and systolic arterial pressure (SAP) above 90 mm Hg
  - Hypotension = MAP < 60 mm Hg, SAP < 90 mm Hg
    - Treat hypotension
    - Decrease anesthetic depth (by decreasing vaporizer concentration)
    - Administer IV fluid bolus (10 ml/kg)
    - Administer IV colloids (10 to 20 ml/kg; use only if hemostasis adequate)
    - Ensure adequate surgical hemostasis
    - Replace surgical blood loss at 1:3 ratio—for every milliliter of blood lost during surgery, 3 ml of crystalloid (e.g., lactated Ringer's solution [LRS]) is administered IV

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- Hemorrhage resulting in PCV < 20% requires blood transfusion or hemoglobin-substitute administration
- Administration of inotrope (e.g., dopamine) IV

▪ Ventilation

□ Exercise caution with manual or mechanical ventilation unless the absence of pneumothorax is confirmed radiographically

□ Capnography (measures amount of expired carbon dioxide [CO_2] at the end of expiration [end-tidal CO_2, or $EtCO_2$])

- Normal $EtCO_2$ = 35 to 45 mm Hg
- Hypoventilation ($EtCO_2$ > 45 mm Hg) may require assisted or mechanical ventilation; if any degree of pneumothorax is present, consider placement of chest tube and continuous suction during ventilation

7.2 CANINE OPHTHALMIC SURGERY

7.2.1 Preanesthesia

▪ With regard to blood work, at a minimum, PCV, TP, blood glucose, and BUN should be measured

▪ An IV catheter is placed for the administration of anesthetic agents and fluids

▪ Exercise caution with restraint and handling, especially if globe is open

7.2.1.1 Premedication

7.2.1.1.1 Agents (mg/kg IM; use half if administering IV)

Oxymorphone* 0.5-0.2 + acepromazine 0.02-0.05 ± glycopyrrolate 0.01

Morphine* 0.5-1 + acepromazine 0.02-0.05 ± glycopyrrolate 0.01

Buprenorphine 0.01-0.02 + acepromazine 0.02-0.05 ± glycopyrrolate 0.01

Midazolam† (or diazepam) 0.1-0.3 can be substituted as a sedative

* Mu-opiate administration can lead to long-lasting miosis, which can prohibit intraocular surgery.

† Benzodiazepines combined with opiates as premedicants frequently cause vomiting, which increases intraocular pressure. Acepromazine has antiemetic effects and lowers the incidence of vomiting.

7.2.2 Induction

- Propofol lowers intraocular pressure
- Thiopental lowers intraocular pressure
- Ketamine and benzodiazepine induction may lead to increased intraocular pressure and is not recommended
- Opiate and benzodiazepine induction has no direct effect on intraocular pressure but may lead to hypoventilation or apnea, which indirectly increases intraocular pressure

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- Inhalant induction by face mask is acceptable if patient is not struggling

7.2.2.1 Five Induction Methods for Anesthesia for Ophthalmic Surgery

7.2.2.1.1 Agents (mg/kg IV); give only until effective

Propofol 4–6

Thiopental 10

Ketamine 5 + diazepam (or midazolam) 0.25

Oxymorphone (or hydromorphone) 0.1 + diazepam 0.2

Mask with inhalant

7.2.3 Analgesia

- Constant-rate infusion of analgesic agent during surgery
- Patients given a neuromuscular blocking agent will not move in response to painful surgical stimulation; administer analgesics and monitor HR and blood pressure for indications of pain

7.2.4 Constant-Rate Infusion

Agent	Loading Dose (mg/kg IV)	Infusion Rate (µg/kg/hr IV)	Isoflurane MAC Reduction (%)
Fentanyl*	0.01–0.05†	1–5	20–54
Morphine*	0.5–1†	100–150	30–50
Ketamine	0.2–0.5	100–300	20–73
Lidocaine	1–2	50–200	20–40

MAC, Minimum alveolar concentration.

* Opiates are profound respiratory depressants and may necessitate mechanical ventilation of patient during infusion.

† Bradycardia may result and can be prevented by administration of atropine (0.02 mg/kg IV) or glycopyrrolate (0.01 mg/kg IV) before loading dose.

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7.2.5 Maintenance

- IV fluids must be administered during anesthesia at a rate of 10 ml/kg/hr

7.2.6 Neuromuscular Blockade

- Intraocular surgery requires centrally located pupil
- Nondepolarizing neuromuscular blocking agents paralyze skeletal muscle
- Mechanical ventilation is necessary; set tidal volume to 10 to 20 ml/kg, respiratory rate to 6 to 12 breaths per minute, and peak inspiratory pressure to < 20 cm Hg
- Monitor degree of neuromuscular blockade with a peripheral nerve stimulator

7.2.7 Nondepolarizing Neuromuscular Blocking Agents

Agent	Initial Dose (mg/kg IV)	Repeat Dose (mg/kg IV)
Atracurium	0.25	0.1
Pancuronium	0.06–0.1	0.05
Vecuronium	0.1–0.2	0.05

7.2.8 Monitoring

- Neuromuscular paralysis monitored with peripheral nerve stimulator
  - Objectively monitors degree of skeletal muscle paralysis by determining percentage of neuromuscular receptors “blocked” by the paralytic agent
  - Place nerve stimulator contact heads around the peripheral nerve to be stimulated
  - Place one of the two contacts on each side of the nerve
  - Most commonly used nerves are peroneal, ulnar, and facial

- Train-of-four (TOF): stimulus for TOF is delivered as a total of four pulses (low frequency, 2 to 4 Hz, for 2 seconds at 0.5-second intervals); aim is to keep only one or two twitches (of a possible four) visible 223 224
- Four twitches are present with no or up to 75% blockade
- Three twitches are present with 75% blockade
- Two twitches are present with 80% blockade
- One twitch is present with 90% blockade
- Zero twitches indicate 100% blockade
- Tetany: continuous stimulation at either 50 or 100 Hz; sensitive to both residual and deep paralysis; the presence of any persisting strength during tetany is good indicator of the patient's ability to maintain muscle tone
- Reversal of blockade is difficult unless at least one twitch in TOF is present

- Reversal of neuromuscular blockade
  - Requires accumulation of acetylcholine at neuromuscular junction and competitive inhibition
  - Use anticholinesterase inhibitors
    - Neostigmine and edrophonium
  - These agents are also muscarinic agonists and may cause bradycardia
  - Administer anticholinergic (atropine 0.02 mg/kg or glycopyrrolate 0.01 mg/kg IV) before anticholinesterase inhibitor to prevent bradycardia

7.2.9 Anticholinesterase Agents

Agent	Dose (mg/kg IV)
Edrophonium*	0.5–1
Neostigmine*	0.1–0.2

* Duration of action shorter than that of nondepolarizing neuromuscular agents; may need to readminister.

- ECG:
  - Tachycardia (HR > 200 bpm)
    - Consider source of tachycardia
    - Ensure adequate anesthetic depth
    - Treat pain with analgesic (e.g., oxymorphone 0.05 mg/kg IM or IV) 224

- Evaluate blood pressure (hypotension can result in reflex tachycardia)

- Blood pressure
  - Hypertension in paralyzed patient indicates inadequate anesthetic depth
  - Administer analgesic (e.g., oxymorphone 0.05 mg/kg IM or IV)
- Ventilation
  - Mechanical ventilation *imperative* if using neuromuscular blockade
  - Arterial blood gas analysis
    - Normal arterial CO_2 = 35 to 45 mm Hg
  - Capnography (measures $EtCO_2$)
    - Normal $EtCO_2$ = 35 to 45 mm Hg

7.3 CESAREAN SECTION IN DOGS AND CATS

General anesthesia is needed to induce pain relief, unconsciousness, and relaxation during cesarean section. In a typical case the pet receives a preanesthetic sedative-analgesic combination and an induction agent and, subsequently, inhalation anesthesia.

7.3.1 Preanesthesia

- Preoperative tests depend in part on the age and general health of the pet; in younger otherwise healthy females, minimal tests are needed
- With regard to blood work, at a minimum, PCV, TP, and blood glucose should be measured
- In older or unhealthy animals it may be necessary to perform a routine blood count, serum biochemical tests, a urinalysis, and possibly a chest x-ray examination or ECG before anesthesia; the need for such tests varies on a case-by-case basis and depends on the overall health of the pet at the time of anesthesia
- Administer analgesic with or without a sedative agent
- Anticholinergics (glycopyrrolate or atropine) decrease salivation and prevent excess vagal tone during uterine traction
- Fetal cardiac output is dependent on fetal HR (not blood pressure), and it is imperative to prevent bradycardia by administering an anticholinergic
- Atropine crosses the placental barrier and increases fetal HR; glycopyrrolate does not; atropine is the agent of choice in patients undergoing cesarean section
- An IV catheter is placed for the administration of anesthetic agents and fluids

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7.3.2 Premedication

Species	Agents (mg/kg IM; Use Half if Administering IV)
Dogs	Oxymorphone 0.05–0.1 ± midazolam (or diazepam) 0.1–0.3 + glycopyrrolate 0.01
Cats	Oxymorphone 0.02–0.08 ± midazolam (or diazepam) 0.1–0.3 + glycopyrrolate 0.01

7.3.3 Induction

- Propofol is the agent of choice because of rapid clearance, minimal hepatic metabolism, and minimal cardiac depression
- Respiratory depression or apnea may occur with large boluses of propofol given rapidly IV; it is recommended that half the calculated induction dose be given over 60 seconds; preoxygenation (oxygen administered via face mask for 5 minutes) before induction prevents maternal and fetal hypoxemia
- Inhalant induction by face mask is acceptable only if patient is not vomiting
- Monitor ventilation after induction and once patient is placed in dorsal recumbency, as increased abdominal volume may inhibit diaphragmatic movement
- Mechanical ventilation may be required in large-breed dogs or patients that have great abdominal distention

7.3.4 Induction

Species	Agents (mg/kg IV)
Dogs	Propofol 4–6
	Ketamine 5 + diazepam 0.25
	Thiopental 10
	Mask with isoflurane or sevoflurane
Cats	Propofol 4–6
	Ketamine 5 + diazepam 0.25
	Thiopental 10
	Mask with isoflurane or sevoflurane

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7.3.5 Maintenance

- Before surgery an epidural block can be performed, but care should be taken not to prolong anesthetic time, as the risk of increased anesthetic time outweighs the benefit of epidural analgesia
- All inhalant anesthetics cross the placental barrier and will reach the fetus
- The most rapidly acting, minimally metabolized inhalant agents are preferable
- Isoflurane and sevoflurane are preferred over halothane

7.3.6 Monitoring

- ECG
  - Prevent bradycardia (HR < 60 bpm in large dogs; HR < 80 bpm in small dogs and cats)
    - Treat bradycardia with atropine 0.01 mg/kg IM or IV
  - Prevent tachycardia (HR > 160 bpm in large dogs; HR > 200 in small dogs and cats)
    - Consider source of tachycardia
    - Treat pain with analgesic (e.g., oxymorphone 0.01 mg/kg IM or IV)
    - Ensure adequate anesthetic depth
    - Evaluate blood pressure (hypotension can result in reflex tachycardia)
- Blood pressure should be monitored, and MAP maintained above 60 mm Hg
  - Hypotension = MAP < 60 mm Hg
    - Treat hypotension
      - Decrease anesthetic depth (by decreasing vaporizer concentration)
      - Administer IV fluid bolus 10 ml/kg
      - Ensure adequate surgical hemostasis
      - Replace surgical blood loss at 1:3 ratio—for every milliliter of blood lost during surgery, 3 ml of crystalloid (e.g., LRS) is administered IV
      - Administer ephedrine 0.025 to 0.05 mg/kg IV

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- Ventilation
  - Capnography (measures $EtCO_2$)
    - Normal $EtCO_2$ = 35 to 45 mm Hg
    - Most cesarean section patients hypoventilate during anesthesia and have $EtCO_2$ > 45 mm Hg; treat with assisted or mechanical ventilation
- Depth of anesthesia

7.3.6.1 Newborns

- Dry immediately after delivery

- Ensure presence of heartbeat and breathing
  - Weak or absent heartbeat: treat with atropine, one drop from 25-gauge needle under tongue
  - Minimal respiratory efforts: treat with 100% oxygen by face mask and doxapram (Dopram), one drop from 25-gauge needle under tongue
  - No suckle reflex, weak heartbeat, and minimal respiratory efforts: treat with naloxone + atropine + doxapram, one drop of each via 25-gauge needle under tongue
- Ensure normothermia
  - Place in box with recirculation heating pad and dry towels
  - Use forced-air heating unit if available (or carefully use blow-dryer to warm and dry newborns)
- Place newborns with dam as soon as she is awake from anesthesia
- Monitor dam and newborns for cannibalism until discharge from hospita

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7.4 FELINE DIABETIC PATIENTS

7.4.1 Preanesthesia

- With regard to blood work, at a minimum, PCV, TP, and blood glucose should be measured
- Patient should be fasted no longer than 6 hours
- Administer half the normal dose of insulin before premedication or induction
- Perform anesthesia early in day
- Place IV catheter for administration of anesthetic agents, fluids, and glucose if necessary
- Use of sterile technique for catheter placement and surgery is imperative, as diabetic patients are prone to infection

7.4.1.1 Premedication

7.4.1.1.1 Agents (mg/kg IM; use half if administering IV)

Oxymorphone 0.03-0.08 + midazolam (or diazepam)* 0.1-0.3 ± glycopyrrolate 0.01

Morphine 0.4-0.8 + midazolam (or diazepam)* 0.1-0.3 ± glycopyrrolate 0.01

Buprenorphine 0.01-0.02 + midazolam (or diazepam)* 0.1-0.3 ± glycopyrrolate 0.01

* Acepromazine 0.02-0.05 can be substituted as a sedative only if patient is well hydrated; vasodilation and hypotension may result.

7.4.2 Induction

- Propopfol has no effect on blood glucose concentration or glucose metabolism; give half the calculated induction dose over 60 seconds; preoxygenate (with oxygen administered via face mask for 5 minutes) before induction to prevent hypoxemia
- Thiopental may increase plasma glucose concentration

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- Ketamine and benzodiazepine induction may lead to tachycardia or arrhythmias and should be used with caution; contraindicated in cats that also have hyperthyroidism
- Opiate and benzodiazepine induction is acceptable
- Inhalant induction by face mask is acceptable

7.4.2.1 Induction

7.4.2.1.1 Agents (mg/kg IV); give only until effective

Propofol 4-6 (use caution if hypovolemia or hypotension is present)

Thiopental 10

Ketamine 5 + diazepam (or midazolam) 0.25 (watch for arrhythmias)

Oxymorphone (or hydromorphone) 0.1 + diazepam 0.2

Mask with inhalant

7.4.3 Maintenance

- Achievement of rapid induction and recovery is the goal; isoflurane and sevoflurane are preferable to halothane
- IV fluids (with or without the addition of 50% dextrose) must be administered during anesthesia at a rate of 10 ml/kg/hr

7.4.4 Monitoring

- Blood glucose measured every 30 to 60 minutes
  - Correct hypoglycemia (< 80 mg/dl) with 5% dextrose at 5 to 10 ml/kg/hr
  - Correct hyperglycemia (> 300 mg/dl) with regular insulin 1 U/kg subcutaneously

- ECG
  - Watch for bradycardia secondary to hypoglycemia
- Body temperature
  - Maintain normothermia
  - Keep patient dry

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- Blood pressure

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  - Maintain MAP above 60 mm Hg
  - Maintain SAP above 90 mm Hg

7.4.5 Recovery

- Administer food as soon as patient is awake
- Resume insulin protocol
- Reduce stress to patient

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7.5 FELINE HYPERTROPHIC CARDIOMYOPATHY

This disease can be seen in cats of any age and is characterized by eccentric hypertrophy and global hypokinesis (systolic dysfunction) of the myocardium. Other diseases that may also be present in affected patients are hyperthyroidism and renal disease.

7.5.1 Preanesthesia

- With regard to blood work, at a minimum, PCV, TP, blood glucose, BUN, creatinine, and thyroid hormone levels should be measured; if patient is receiving aspirin therapy (thromboembolic preventative), a coagulation panel (prothrombin time [PT] and partial thromboplastin time [PTT]), platelet number, and buccal mucosal bleeding time (BMBT) should be obtained before surgery
- Take thoracic radiographs to evaluate cardiac size and rule out presence of heart failure (pleural effusion or pulmonary edema)
- Perform complete cardiovascular examination, including echocardiography and ECG, to evaluate cardiac performance
- Continue administration of previously prescribed cardiac medications
- Place an IV catheter for the administration of anesthetic agents and crystalloid or colloids during anesthesia

- Cats showing any signs of heart failure have a greatly increased risk of an adverse anesthetic outcome and should be anesthetized with extreme caution even for routine procedures

7.5.1.1 Premedication

7.5.1.1.1 Agents (mg/kg IM; use half if administering IV)

Oxymorphone* 0.03-0.08 + acepromazine† 0.02-0.08 ± glycopyrrolate 0.01

Morphine* 0.4-0.8 + midazolam (or diazepam) 0.1-0.3 ± glycopyrrolate 0.01

Buprenorphine 0.01-0.02 + midazolam (or diazepam) 0.1-0.3 ± glycopyrrolate 0.01

* Mu-opiate and benzodiazepine administration may lead to hypoventilation; use with caution, as this may result in hypercapnia and increased intracranial pressure.

† Acepromazine should be administered cautiously. Do not administer to hypovolemic or dehydrated patients.

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7.5.2 Induction

- Etomidate is the agent of choice in any patient with cardiac disease, as it does not affect either HR or blood pressure; use only in premedicated or well-sedated patients, as excitement may occur during administration; administer along with benzodiazepine (diazepam or midazolam) to decrease incidence of excitement
- Propofol is acceptable for use in well-hydrated patients; administer half the calculated induction dose over 60 seconds; preoxygenate (with oxygen administered via face mask for 5 minutes) before induction to prevent hypoxemia
- Opiate and benzodiazepine induction is acceptable, provided that adequate premedication or sedation exists; as with etomidate, excitement may occur during administration; bradycardia may result and can be prevented or treated with anticholinergic administration; care must be taken to avoid tachycardia
- Inhalant induction by face mask is acceptable only if patient is well premedicated or sedated and does not struggle or become stressed
- Thiopental should be avoided, as it induces tachycardia, increases peripheral vascular resistance, increases myocardial oxygen consumption, and may induce cardiac arrhythmias

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- Ketamine and benzodiazepine combinations for induction should be avoided; ketamine increases HR, cardiac contractility, cardiac output, and systemic blood pressure

7.5.2.1 Induction

7.5.2.1.1 Agents (mg/kg IV)

Diazepam 0.2 (or midazolam 0.2) immediately followed by etomidate 1-2

Propofol 4-6

Oxymorphone (or hydromorphone) 0.1 + diazepam 0.2 (or midazolam 0.2)

Mask with isoflurane or sevoflurane

7.5.3 Analgesia

- Brachial plexus block if performing surgery on forelimb
- Paw block if performing onychectomy (declawing)
- Epidural administration if performing surgery on hindlimb; if performed before surgery, allows decreased inhalant requirement during surgery and provides postoperative analgesia for up to 24 hours (if preservative-free morphine is used)
- Fentanyl patch placement before surgery (blood levels of fentanyl and therefore analgesia are not present for 8 to 12 hours after placement; provides only postoperative analgesia); monitor patients with intracranial lesions for respiratory depression
- Constant-rate infusion of analgesic agent during surgery; careful monitoring of ventilation in patients with intracranial lesions; opiate constant-rate infusion causes hypoventilation, and mechanical ventilation is necessary; monitor ventilation

7.5.4 Constant-Rate Infusion

Agent	Loading Dose (mg/kg IV)	Infusion Rate (µg/kg/hr IV)	Isoflurane MAC Reduction (%)
Fentanyl*	0.005–0.01†	1–3	20–40
Morphine*	0.5–0.8†	100–120	30–40
Lidocaine	0.5–1	50–100	20–30

* Opiates are profound respiratory depressants, and patients with intracranial lesions should receive mechanical ventilation during infusion.

† Bradycardia may result and can be prevented by administration of atropine (0.02 mg/kg IV) or glycopyrrolate (0.01 mg/kg IV) before loading dose if HR is less than 100 bpm. The goal is to keep the patient's HR within 20% of preinduction values.

7.5.5 Maintenance

- The most rapidly acting inhalant agents are preferred

- Isoflurane and sevoflurane are preferred over halothane; halothane sensitizes the myocardium to catecholamine-induced arrhythmias

- Balanced electrolyte fluids (not 0.9% NaCl) are administered IV during anesthesia at a decreased rate of 3 to 5 ml/kg/hr; increases in intravascular fluid volume may increase blood pressure

- Avoid tachycardia and hypertension

7.5.6 Monitoring

- ECG: watch for arrhythmias

  - Prevent bradycardia (HR < 60 bpm)

    - Treat bradycardia with atropine 0.01 mg/kg IV or glycopyrrolate 0.005 mg/kg IV

  - Prevent tachycardia (HR > 200 bpm)

    - Consider source of tachycardia

    - Treat pain with analgesic (e.g., oxymorphone 0.05 mg/kg IM or IV)

    - Ensure adequate anesthetic depth

    - Evaluate blood pressure (hypotension can result in reflex tachycardia)

    - Administer beta-adrenergic–receptor antagonist (e.g., propranolol 0.04 mg/kg IV)

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- Blood pressure should be monitored, and MAP maintained above 60 mm Hg and SAP above 90 mm Hg

  - Hypotension = MAP < 60 mm Hg, SAP < 90 mm Hg

    - Treat hypotension

      - Decrease anesthetic depth (by decreasing vaporizer concentration)

      - Do not administer crystalloid fluids as a bolus

      - Administer IV colloids 10 to 20 ml/kg IV over 30 minutes

      - Hemorrhage resulting in PCV < 20% requires blood transfusion or hemoglobin-substitute administration

      - Administer inotrope (e.g., dopamine or dobutamine) IV

- Ventilation

  - Capnography (measures $EtCO_2$)

    - Normal $EtCO_2$ = 35 to 45 mm Hg

- Hypoventilation ($EtCO_2$ > 45 mm Hg) requires assisted or mechanical ventilation or adjustments in ventilation, as increases in blood pressure may result

- Arterial blood gas analysis of CO_2
  - More accurate than capnography
  - Normal $Paco_2$ = 35 to 45 mm Hg
  - Hypoventilation ($Paco_2$ > 45 mm Hg) requires immediate assisted or mechanical ventilation or adjustments in ventilation, as increases in blood pressure may result

- Temperature
  - Objective is normothermic patient; slight hypothermia (1° to 3°C decrease from normal body temperature) is acceptable

7.5.7 Recovery

- Ensure quiet and smooth recovery from anesthesia
- Keep patient in stimulus-free environment
- Dry patient if it is wet
- Shivering increases metabolic oxygen consumption by up to 200% and should be avoided; aggressively warm patient with recirculating heating pad, plastic bubble wrap, aluminum body wrap, warmed IV fluids, warm water bottles, or forced-air heating units

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7.6 CANINE UROLITHIASIS

Most dogs without complete urethral obstruction can be heavily sedated for urethral hydropulsion. If this fails, decompression of the bladder by cystocentesis or emergency urethrotomy and general anesthesia are required.

7.6.1 Preanesthesia

- Preoperative tests depend on degree of blockage present
  - Patients with partial urinary blockage may appear relatively healthy on presentation
  - Patients with complete blockage for a long duration may be moribund on presentation
- With regard to blood work, at a minimum, PCV, TP, blood glucose, BUN, creatinine, and calcium and potassium levels should be measured
- Treat hyperkalemia (K^+ > 6 mEq/L before anesthesia) and hypercalcemia (Ca^{+2} > 11 mg/dl before anesthesia)

- Hyperkalemia can be treated with insulin (1 U/kg IM or IV; insulin shifts potassium from extracellular fluid into cells) along with 50% dextrose (2 g per unit of insulin administered) to prevent hypoglycemia from insulin administration
- Perform ECG, particularly if hyperkalemia is present. Monitor for peaked T waves, P-wave abnormalities or absence, widening of QRS complex, sinoatrial rhythm
    - 10% calcium gluconate 1 to 1.5 ml/kg IV can be administered over 10 minutes to reduce cardiotoxic effects of hyperkalemia
- Treat hypercalcemia with IV NaCl (calcium- and potassium-free fluid)
- Treat acid-base abnormalities (metabolic acidosis most commonly seen; treat with sodium bicarbonate)
    - 0.7×base deficit × body weight (kg)=HCO_3^- (mEq)

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    - Administer half this amount IV over 30 minutes, and reassess patient
- Anticholinergics (glycopyrrolate or atropine) should be administered only if patient is bradycardic and normokalemic
- An IV catheter is placed for the administration of anesthetic agents and fluids
- Correct dehydration with IV NaCl (calcium- and potassium-free fluid) based on level of dehydration

7.6.1.1 Premedication*

7.6.1.1.1 Agents (mg/kg IM; use half if administering IV)—can be repeated if necessary

Oxymorphone 0.1-0.2 + midazolam (or diazepam)† 0.1-0.3 ± glycopyrrolate 0.01

Morphine 0.5-1 + midazolam (or diazepam)† 0.1-0.3 ± glycopyrrolate 0.01

Buprenorphine 0.01-0.02 + midazolam (or diazepam)† 0.1-0.3 ± glycopyrrolate 0.01

* Can be used for urinary catheter placement and before induction and general anesthesia.

† Acepromazine 0.02-0.05 can be substituted as a sedative only if patient is well hydrated, as vasodilation and hypotension may result.

7.6.2 Induction

- Propofol is the agent of choice because of its rapid clearance, minimal hepatic metabolism, minimal renal effects, and minimal cardiac depression

- Respiratory depression or apnea may occur if large boluses of propofol are given rapidly IV; it is recommended that half the calculated induction dose be given over 60 seconds; preoxygenate (with oxygen administered via face mask for 5 minutes) before induction to prevent hypoxemia
- Inhalant induction by face mask is acceptable only if patient is not vomiting

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7.6.2.1 Induction

7.6.2.1.1 Agents (mg/kg IV); give only until effective

Propofol 4-6

Thiopental 10

Oxymorphone (or hydromorphone) 0.1 + diazepam 0.2

Mask with isoflurane or sevoflurane

7.6.3 Maintenance

- The most rapidly acting, minimally metabolized inhalant agents are preferred
  - Isoflurane and sevoflurane are preferred over halothane
- IV fluids (NaCl if hyperkalemia or hypercalcemia is present) must be administered during anesthesia at a rate of 10 ml/kg/hr and continued postoperatively after obstruction has been relieved

7.6.4 Monitoring

- ECG: watch for signs of hyperkalemia
  - Prevent bradycardia (HR < 60 bpm)
    - Treat bradycardia with atropine 0.01 mg/kg IM or IV
  - Prevent tachycardia (HR > 200 bpm)
    - Consider source of tachycardia
    - Treat pain with analgesic (e.g., oxymorphone 0.05 mg/kg IM or IV)
    - Ensure adequate anesthetic depth
    - Evaluate blood pressure (hypotension can result in reflex tachycardia)
- Blood pressure should be monitored, and MAP maintained above 60 mm Hg and SAP above 90 mm Hg
  - Hypotension = MAP < 60 mm Hg, SAP < 90 mm Hg

- Treat hypotension
  - Decrease anesthetic depth (by decreasing vaporizer concentration)
  - Administer IV fluid bolus 10 ml/kg

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  - Ensure adequate surgical hemostasis

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  - Replace surgical blood loss at 1:3 ratio—for every milliliter of blood lost during surgery, 3 ml of crystalloid (e.g., LRS) is administered IV
  - Administer inotrope (dopamine) IV

- Ventilation
  - Capnography (measures $EtCO_2$)
    - Normal $EtCO_2$ = 35 to 45 mm Hg
    - Most patients have a preexisting metabolic acidosis
    - Hypoventilation increases CO_2 and creates a respiratory acidosis that further compromises the patient

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7.7 FELINE UROLITHIASIS

Many cats without complete urethral obstruction can be heavily sedated for urethral hydropulsion. If this fails, decompression of the bladder by cystocentesis or emergency urethrotomy and general anesthesia are required.

7.7.1 Preanesthesia

- Preoperative tests depend on degree of blockage present
  - Patients with partial urinary blockage may be relatively healthy on presentation
  - Patients with complete blockage for a long duration may be moribund on presentation
- With regard to blood work, at a minimum, PCV, TP, blood glucose, BUN, creatinine, and calcium and potassium levels should be measured
- Hypercalcemia occurs in approximately one third of cats with calcium oxalate stones
- Treat hyperkalemia (K^+ > 6 mEq/L before anesthesia) and hypercalcemia (Ca^{+2} > 11 mg/dl before anesthesia)
- Hyperkalemia can be treated with insulin (1 U/kg IM or IV; insulin shifts potassium from extracellular fluid into cells) along with 50% dextrose (2 g per unit of insulin administered) to prevent hypoglycemia resulting from insulin administration

- Perform ECG, particularly if hyperkalemia present; monitor for peaked T waves, P-wave abnormalities or absence, widening of QRS complex, sinoatrial rhythm
    - 10% calcium gluconate 1 to 1.5 ml/kg IV can be administered over 10 minutes to reduce cardiotoxic effects of hyperkalemia
- Treat hypercalcemia with IV NaCl (calcium- and potassium-free fluid); do not use if patient is already hypercalcemic
- Treat acid-base abnormalities (metabolic acidosis most commonly seen; treat with sodium bicarbonate) 243 244
    - 0.7 × base deficit × body weight (kg) = HCO_3^- (mEq)
    - Administer half this amount IV over 30 minutes, and reassess patient
- Anticholinergics (glycopyrrolate or atropine) should be administered only if patient is bradycardic and normokalemic
- An IV catheter is placed for the administration of anesthetic agents and fluids
- Dehydration is corrected with IV NaCl (calcium- and potassium-free fluid) based on level of dehydration

7.7.1.1 Premedication*

7.7.1.1.1 Agents (mg/kg IM; use half if administering IV)—can be repeated if necessary

Oxymorphone 0.03-0.08 + midazolam (or diazepam)† 0.1-0.3 ± glycopyrrolate 0.01

Morphine 0.4-0.8 + midazolam (or diazepam)† 0.1-0.3 ± glycopyrrolate 0.01

Buprenorphine 0.01-0.02 + midazolam (or diazepam)† 0.1-0.3 ± glycopyrrolate 0.01

* Can be used for urinary catheter placement and before induction and general anesthesia.

† Acepromazine 0.02-0.05 can be substituted as a sedative only if patient is well hydrated, as vasodilation and hypotension may result.

7.7.2 Induction

- Propofol is the agent of choice because of rapid clearance, minimal hepatic metabolism, minimal renal effects, and minimal cardiac depression
- Respiratory depression or apnea may occur with large boluses of propofol given rapidly IV; it is recommended that half the calculated induction dose be given over 60 seconds; preoxygenation (with oxygen administered via face mask for 5 minutes) before induction prevents hypoxemia 244 245
- Inhalant induction by face mask is acceptable only if patient is not vomiting

7.7.2.1 Induction

7.7.2.1.1 Agents (mg/kg IV); give only until effective

Propofol 4-6

Thiopental 10

Oxymorphone (or hydromorphone) 0.1 + diazepam 0.2

Mask with isoflurane or sevoflurane

7.7.3 Maintenance

- The most rapidly acting, minimally metabolized inhalant agents are preferred
  - Isoflurane and sevoflurane are preferred over halothane
- IV fluids (NaCl if hyperkalemia or hypercalcemia present) must be administered during anesthesia at a rate of 10 ml/kg/hr and continued postoperatively after obstruction has been relieved

7.7.4 Monitoring

- ECG: watch for signs of hyperkalemia
  - Prevent bradycardia (HR < 60 bpm)
    - Treat bradycardia with atropine 0.01 mg/kg IM or IV
  - Prevent tachycardia (HR > 200 bpm)
    - Consider source of tachycardia
    - Treat pain with analgesic (e.g., oxymorphone 0.05 mg/kg IM or IV)
    - Ensure adequate anesthetic depth
    - Evaluate blood pressure (hypotension can result in reflex tachycardia)
- Blood pressure should be monitored, and MAP maintained above 60 mm Hg and SAP above 90 mm Hg
  - Hypotension = MAP < 60 mm Hg, SAP < 90 mm Hg

    - Treat hypotension
      - Decrease anesthetic depth (by decreasing vaporizer concentration)
      - Administer IV fluid bolus 10 ml/kg

- Ensure adequate surgical hemostasis
- Replace surgical blood loss at 1:3 ratio—for every milliliter of blood lost during surgery, 3 ml of crystalloid (e.g., LRS) is administered IV
- Administer inotrope (dopamine) IV

- Ventilation
  - Capnography (measures $EtCO_2$)
    - Normal $EtCO_2$ = 35 to 45 mm Hg
    - Most patients have a preexisting metabolic acidosis
    - Hypoventilation increases CO_2 and creates a respiratory acidosis that will further compromise the patient

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7.8 CAPRINE UROLITHIASIS

Most goats without complete urethral obstruction can be heavily sedated for urethral hydropulsion. If this fails, decompression of the bladder by cystocentesis or emergency urethrotomy and general anesthesia are required.

7.8.1 Preanesthesia

- Preoperative tests depend on degree of blockage present
  - Patients with partial urinary blockage may appear relatively healthy on presentation
  - Patients with complete blockage for a long duration may be moribund on presentation
- With regard to blood work, at a minimum, PCV, TP, blood glucose, BUN, creatinine, and calcium and potassium levels should be measured
- Treat hyperkalemia (K^+ > 6 mEq/L before anesthesia)
- Hyperkalemia can be treated with insulin (1 U/kg IM or IV; insulin shifts potassium from extracellular fluid into cells) along with 50% dextrose (2 g per unit of insulin administered) to prevent hypoglycemia resulting from insulin administration
- Perform ECG, particularly if hyperkalemia is present; monitor for peaked T waves, P-wave abnormalities or absence, widening of QRS complex, sinoatrial rhythm
  - 10% calcium gluconate 1 to 1.5 ml/kg IV can be administered over 10 minutes to reduce cardiotoxic effects of hyperkalemia
- Treat acid-base abnormalities (metabolic acidosis most commonly seen; treat with sodium bicarbonate)

- 0.7 × base deficit × body weight (kg) = HCO_3^- (mEq)
- Administer half this amount IV over 30 minutes, and reassess patient

- Anticholinergics (glycopyrrolate or atropine) should be administered only if patient is bradycardic and normokalemic

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- An IV catheter is placed for the administration of anesthetic agents and fluids
- Correct dehydration with IV NaCl (calcium- and potassium-free fluid) based on level of dehydration

7.8.1.1 Premedication*

7.8.1.1.1 Agents (mg/kg IM; use half if administering IV)—can be repeated if necessary

Midazolam (or diazepam)† 0.1-0.5 (excellent sedative in goats) ± glycopyrrolate 0.01

Buprenorphine 0.01-0.02 + midazolam (or diazepam)† 0.1-0.3 ± glycopyrrolate 0.01

Morphine 0.2-0.5 + midazolam (or diazepam)† 0.1-0.3 ± glycopyrrolate 0.01

* Can be used for urinary catheter placement and before induction and general anesthesia.

† Acepromazine 0.02-0.05 can be substituted as a sedative only if the patient is well hydrated, as vasodilation and hypotension may result.

7.8.2 Induction

- Propofol is the agent of choice because of rapid clearance, minimal hepatic metabolism, minimal renal effects, and minimal cardiac depression
- Respiratory depression or apnea may occur with large boluses of propofol given rapidly IV; it is recommended that half the calculated induction dose be given over 60 seconds; preoxygenation (with oxygen administered via face mask for 5 minutes) before induction prevents hypoxemia
- Goal is rapid induction; therefore inhalant administered by face mask is *not* the method of choice, as regurgitation or aspiration may result

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7.8.2.1 Induction

7.8.2.1.1 Agents (mg/kg IV); give only until effective

Propofol 4-6

Thiopental 10

Oxymorphone (or hydromorphone) 0.1 + diazepam 0.2

7.8.3 Maintenance

- The most rapidly acting, minimally metabolized inhalant agents are preferred
  - Isoflurane and sevoflurane are preferred over halothane
- IV fluids (NaCl if hyperkalemia or hypercalcemia is present) must be administered during anesthesia at a rate of 10 ml/kg/hr and continued postoperatively after obstruction has been relieved

7.8.4 Monitoring

- ECG: watch for signs of hyperkalemia
  - Prevent bradycardia (HR < 60 bpm)
    - Treat bradycardia with atropine 0.01 mg/kg IM or IV
  - Prevent tachycardia (HR > 200 bpm)
    - Consider source of tachycardia
    - Treat pain with analgesic (e.g., buprenorphine 0.01 mg/kg IM or IV)
    - Ensure adequate anesthetic depth
    - Evaluate blood pressure (hypotension can result in reflex tachycardia)
- Blood pressure should be monitored, and MAP maintained above 60 mm Hg and SAP above 90 mm Hg
  - Hypotension = MAP < 60 mm Hg, SAP < 90 mm Hg
    - Treat hypotension
      - Decrease anesthetic depth (by decreasing vaporizer concentration)
      - Administer IV fluid bolus 10 ml/kg
      - Ensure adequate surgical hemostasis

      - Replace surgical blood loss at 1:3 ratio—for every milliliter of blood lost during surgery, 3 ml of crystalloid (e.g., LRS) is administered IV
      - Administer inotrope (dopamine) IV
- Ventilation
  - Capnography (measures $EtCO_2$)

- Normal $EtCO_2$ = 35 to 45 mm Hg
- Most patients have a preexisting metabolic acidosis
- Hypoventilation increases CO_2 and creates a respiratory acidosis that will further compromise the patient

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7.9 RUPTURED BLADDER IN FOALS

This condition is commonly seen in 3- to 5-day-old foals. The presence of urine in the abdomen leads to systemic problems as it causes alteration of electrolyte levels in the blood. Urine is high in potassium and low in sodium, whereas the blood content is opposite. Blood potassium levels can be high enough to cause cardiac arrhythmias in some cases. The decreased blood sodium level affects hydration also, as water always follows sodium. Surgery is not indicated until the foal's condition is stable.

7.9.1 Preanesthesia

- With regard to blood work, at a minimum, PCV, TP, blood glucose, and BUN should be measured
- An IV catheter is placed for the administration of anesthetic agents and resuscitation fluids; in addition, hypertonic saline and colloids can be administered
- Correct dehydration with IV NaCl (potassium-free fluid) based on level of dehydration
- Treat all electrolyte and acid-base disorders before anesthesia
- Hyperkalemia can be treated with insulin (1 U/kg IM or IV; insulin shifts potassium from extracellular fluid into cells) along with 50% dextrose (2 g per unit of insulin administered) to prevent hypoglycemia resulting from insulin administration
  - 10% calcium gluconate 1 to 1.5 ml/kg IV can be administered over 10 minutes to reduce cardiotoxic effects of hyperkalemia
- Treat acid-base abnormalities (metabolic acidosis most commonly seen; treat with sodium bicarbonate)
  - 0.7 × base deficit × body weight (kg) = HCO_3^- (mEq)
  - Administer half this amount IV over 30 minutes, and reassess patient

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7.9.1.1 Premedication

7.9.1.1.1 Agents (mg/kg IM; use half if administering IV)

Diazepam (or midazolam) 0.1-0.2

Butorphanol 0.05-0.2

Xylazine*

* Not recommended in foals younger than 21 days because of hepatic immaturity.

7.9.2 Induction

- Inhalant induction by face mask or nasopharyngeal tube is the method of choice in any foal younger than 21 days; pass nasotracheal tube (8 to 12 mm internal diameter cuffed) lubricated with lidocaine 2% jelly; ensure placement in trachea by visualization of condensation with expiration and auscultation of breath sounds; administer inhalant via nasotracheal tube until foal is asleep; replace nasotracheal tube with endotracheal tube unless mechanical ventilation is planned
- Propofol may induce respiratory depression; use with caution in patients with uncorrected hypovolemia; give half the calculated induction dose over 60 seconds; preoxygenate (with oxygen administered via face mask for 5 minutes) before induction to prevent hypoxemia

7.9.2.1 Induction*

7.9.2.1.1 Agents (mg/kg IV); give only until effective

Propofol 4-6

Mask with isoflurane or sevoflurane at 2-3 × MAC

* MAC, Minimum alveolar concentration.

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7.9.3 Maintenance

- The most rapidly acting, minimally metabolized inhalant agents are preferred
  - Isoflurane and sevoflurane are preferred over halothane
- IV fluids must be administered during anesthesia at a rate of 10 ml/kg/hr

7.9.4 Monitoring

- ECG: watch for arrhythmia, signs of hyperkalemia (peaked T waves, P-wave abnormalities or absence, widening of QRS complex, sinoatrial rhythm)
  - Prevent bradycardia (HR < 60 bpm); cardiac output of foal is dependent on HR; it is imperative that HR be kept within normal range
    - Treat bradycardia with atropine 0.01 mg/kg IM or IV
- Blood glucose
  - Monitor every 30 to 60 minutes
  - Add dextrose (2.5 to 5%) to fluids if blood glucose < 60 mg/dl

- Blood pressure should be monitored, and MAP maintained above 60 mm Hg and SAP above 90 mm Hg
  - Hypotension = MAP < 60 mm Hg, SAP < 90 mm Hg
    - Treat hypotension
      - Decrease anesthetic depth (by decreasing vaporizer concentration)
      - Administer IV fluid bolus 10 ml/kg
      - Administer IV colloids 10 to 20 ml/kg (use only if hemostasis adequate)
      - Ensure adequate surgical hemostasis
      - Replace surgical blood loss at 1:3 ratio—for every milliliter of blood lost during surgery, 3 ml of crystalloid (e.g., LRS) is administered IV
      - Hemorrhage resulting in PCV < 20% requires blood transfusion or hemoglobin-substitute administration
      - Administer inotrope (e.g., dopamine) IV

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- Ventilation
  - Foals have tendency to hypoventilate and require assisted or mechanical ventilation
  - Capnography (measures $EtCO_2$)
    - Normal $EtCO_2$ = 35 to 45 mm Hg
    - Most patients have a preexisting metabolic acidosis
    - Hypoventilation will increase CO_2 and create a respiratory acidosis that will further compromise the patient
    - Hypoventilation ($EtCO_2$ > 45 mm Hg) requires assisted or mechanical ventilation

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7.10 ADRENALECTOMY IN FERRETS

Ferrets can have cardiomyopathy, anemia, and other endocrine diseases such as insulinoma. Exercise caution with respect to restraint and stress to patient. Protect against being bitten.

7.10.1 Preanesthesia

- If possible, obtain ferret donor for possible blood transfusion
  - If this is impossible, Oxyglobin is a suitable blood substitute
- Obtain accurate weight using gram scale

- With regard to blood work, at a minimum, PCV, TP, and blood glucose should be measured
- Patient should be fasted no longer than 4 hours
- Place IV catheter for administration of anesthetic agents, fluids, and glucose if necessary; warm skin to facilitate venous dilation and visualization of vessel; cephalic, medial, or lateral saphenous and jugular veins are easily catheterized using 22- or 25-gauge catheter

7.10.1.1 Premedication

7.10.1.1.1 Agents (mg/kg IM; use half if administering IV)

Oxymorphone 0.03-0.2 + midazolam (or diazepam)* 0.5-2 ± glycopyrrolate 0.01

Buprenorphine 0.01-0.03 + midazolam (or diazepam)* 0.5-2 ± glycopyrrolate 0.01

Morphine 0.4-0.8 + ketamine 5-10 ± glycopyrrolate 0.01

* Acepromazine 0.02-0.05 can be substituted as a sedative only if patient is well hydrated; vasodilation and hypotension may result.

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7.10.2 Induction

- Ferrets are easily intubated using laryngoscope (or otoscope) and 2- to 3.5-mm internal diameter cuffed endotracheal tube; ferrets' teeth are very sharp
- Lidocaine 2% 0.1 ml can be topically applied to larynx to facilitate intubation
- Rubber band can be used to secure tube
- Propofol allows rapid induction and minimal laryngospasm; give half the calculated induction dose over 60 seconds; preoxygenate (with oxygen administered via face mask for 5 minutes) before induction to prevent hypoxemia
- Thiopental is acceptable; however, resulting splenic sequestration of red blood cells may lower PCV
- Ketamine and benzodiazepine induction is acceptable
- Opiate and benzodiazepine induction is acceptable
- Inhalant induction by face mask is acceptable

7.10.2.1 Induction

7.10.2.1.1 Agents (mg/kg IV); give only until effective

Propofol 4-6

Thiopental 10

Ketamine 5 + diazepam (or midazolam) 0.25

Oxymorphone (or hydromorphone) 0.1 + diazepam 0.2

Mask with inhalant

7.10.3 Maintenance

- Achievement of rapid induction and recovery is goal; isoflurane and sevoflurane are preferable to halothane
- If unable to perform endotracheal intubation, can maintain on inhalant via face mask
- Use nonrebreathing anesthesia circuit (e.g., Bain circuit)

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- Warmed IV fluids (with or without 50% dextrose added) must be administered during anesthesia at a rate of 5 to 10 ml/kg/hr

7.10.4 Monitoring

- Depth of anesthesia
  - Loss of righting and pedal reflex indicates surgical plane of anesthesia
- Blood glucose measured every 30 to 60 minutes; hypoglycemia is common
  - Correct hypoglycemia (< 80 mg/dl) with 5% dextrose at 5 to 10 ml/kg/hr
- ECG
  - Watch for bradycardia secondary to hypoglycemia
  - Watch for tachycardia secondary to hypotension or hemorrhage
- Body temperature
  - Maintain normothermia; use recirculating water pad, plastic bubble wrap, aluminum foil, adhesive plastic surgical drapes
  - Use warmed surgical preparation solution; do not use alcohol; use sterile saline
  - Keep patient dry
- Blood pressure
  - Doppler probe can be placed on forelimb, hindlimb, or tail

- Blood pressure cuff can be placed proximal to Doppler ultrasound probe for measurement of systolic blood pressure with sphygmomanometer
- Maintain SAP above 90 mm Hg
  - If hypotension is present (SAP < 90 mm Hg), ensure hemostasis and treat using crystalloids, colloids, blood, Oxyglobin, or vasopressor

- Blood loss
  - Average 1-kg ferret has blood volume of approximately 70 ml; patient cannot lose more than 10% of body weight (7 ml) without detriment

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  - Collect blood from ferret donor before surgery and administer to patient if blood loss exceeds 10 ml or PCV < 20% intraoperatively
  - Ferrets do not have blood groups or types; all ferrets are universal donors
  - If no donor is available, administer Oxyglobin 10 ml/kg IV over 30 minutes; monitor for hypertension and fluid overload

7.10.5 Recovery

- Administer food as soon as patient is awake
- Maintain normothermia
- Minimize handling and stress to patient
- Continue analgesic administration (e.g., buprenorphine 0.01 mg/kg IM or IV every 6 to 8 hours) for at least 24 hours after surgery

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7.11 PATIENTS WITH HISTORY OF SEIZURES OR CENTRAL NERVOUS SYSTEM DISEASE

7.11.1 Preanesthesia

- With regard to blood work, at a minimum, PCV, TP, blood glucose, and BUN should be measured
- An IV catheter is placed for the administration of anesthetic agents and resuscitation fluids
- Central nervous system (CNS) disease includes any neurologic signs, increased intracranial pressure, intracranial lesion, head trauma, or dementia of unknown cause

7.11.2 Premedication

Species	Agents (mg/kg IM; Use Half if Administering IV)
Dogs	Oxymorphone* 0.03–0.2 + midazolam (or diazepam)† 0.1–0.3 ± glycopyrrolate 0.01
	Morphine* 0.5–1 + midazolam (or diazepam)† 0.1–0.3 ± glycopyrrolate 0.01
	Buprenorphine 0.01–0.02 + midazolam (or diazepam)† 0.1–0.3 ± glycopyrrolate 0.01
Cats	Oxymorphone* 0.03–0.08 + midazolam (or diazepam)† 0.1–0.3 ± glycopyrrolate 0.01
	Morphine* 0.4–0.8 + midazolam (or diazepam)† 0.1–0.3 ± glycopyrrolate 0.01
	Buprenorphine 0.01–0.02 + midazolam (or diazepam)† 0.1–0.3 ± glycopyrrolate 0.01
Horses	Xylazine 0.2–0.6

* Mu-opiate and benzodiazepine administration may lead to hypoventila-tion; use with caution, as this may result in hypercapnia and increased intracranial pressure.

† Acepromazine should be avoided, as it may lower the seizure threshold.

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7.11.3 Induction

- Propofol may induce respiratory depression; use with caution in patients with history of seizures or increased intracranial pressure; propofol has been shown to cause seizures and has also been used to treat seizures; its use is controversial in patients with CNS disease; give half the calculated induction dose over 60 seconds; preoxygenate (with oxygen administered via face mask for 5 minutes) before induction to prevent hypoxemia
- Thiopental is the agent of choice for induction of patients with a history of seizures or any intracranial lesion (CNS disease)
- Ketamine and benzodiazepine induction should be avoided; ketamine increases cerebral blood flow and cerebral metabolic oxygen consumption and lowers the seizure threshold
- Opiate and benzodiazepine induction may lead to hypoventilation or apnea; use with caution in patients with intracranial lesions; bradycardia may result and can be prevented or treated with anticholinergic administration
- Inhalant induction by face mask is acceptable in patients with a history of seizures; use is not recommended in patients with intracranial lesions, as many inhalants increase cerebral blood flow

7.11.3.1 Induction in Dogs and Cats

7.11.3.1.1 Agents (mg/kg IV); give only until effective

Propofol 4-6 (watch for hypoventilation and apnea)

Thiopental 10 (watch for hypoventilation and apnea)

Oxymorphone (or hydromorphone) 0.1 + diazepam 0.2 (watch for hypoventilation and apnea)

Mask with isoflurane or sevoflurane

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7.11.3.2 Induction in Horses

7.11.3.2.1 Agents (mg/kg IV)

5% guaifenesin 100 (to achieve ataxia), followed by thiopental 6 (as a rapid bolus)

5% guaifenesin combined with 3 g of thiopental per liter of GG (administered until effective)

7.11.4 Analgesia

- Brachial plexus block if performing surgery on forelimb of dog or cat
- Epidural administration if performing surgery on hindlimb; if performed before surgery, decreases inhalant requirement during surgery and provides postoperative analgesia for up to 24 hours (if preservative-free morphine is used)
- Fentanyl patch placement before surgery (blood levels of fentanyl and therefore analgesia are not present for 8 to 12 hours after placement; provides only postoperative analgesia); monitor patients with intracranial lesions for respiratory depression
- Constant-rate infusion of analgesic agent during surgery; carefully monitor ventilation in patients with intracranial lesions; opiate constant-rate infusion causes hyperventilation, and mechanical ventilation is necessary; monitor ventilation

7.11.5 Constant-Rate Infusion

Agent	Loading Dose (mg/kg IV)	Infusion Rate (µg/kg/hr IV)	Isoflurane MAC Reduction (%)
Fentanyl*	0.01–0.05†	1–5	20–54
Morphine*	0.5–1†	100–150	30–50
Ketamine‡	0.2–0.5	100–300	20–73
Lidocaine	1–2	50–200	20–40

* Opiates are profound respiratory depressants, and patients with intracranial lesions should receive mechanical ventilation during infusion.

† Bradycardia may result and can be prevented by administration of atropine (0.02 mg/kg IV) or glycopyrrolate (0.01 mg/kg IV) before loading dose.

‡ Ketamine should not be administered to patients with a history of seizures.

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7.11.6 Maintenance

- The most rapidly acting inhalant agents are preferred

- Isoflurane and sevoflurane are preferred over halothane

- IV fluids are administered during anesthesia at a decreased rate of 3 to 5 ml/kg/hr; increases in intravascular fluid volume may increase blood pressure and intracranial pressure; aggressive administration of isotonic crystalloids may worsen brain edema by decreasing colloid oncotic pressure
- Avoid 5% dextrose in water (D5W); increases in glucose concentration aggravate cerebral injury
- Avoid hypertension in patients with intracranial lesions

7.11.7 Monitoring

- ECG: watch for arrhythmias (bradycardia may be indicative of Cushing's reflex, characterized by bradycardia and hypertension as a result of increased intracranial pressure)
  - Prevent bradycardia (HR < 60 bpm)
    - Treat bradycardia with atropine 0.01 mg/kg IV or glycopyrrolate 0.005 mg/kg IV
    - Evaluate for increased intracranial pressure
  - Prevent tachycardia (HR > 200 bpm)
    - Consider source of tachycardia
    - Treat pain with analgesic (e.g., oxymorphone 0.05 mg/kg IM or IV)
    - Ensure adequate anesthetic depth
    - Evaluate blood pressure (hypotension can result in reflex tachycardia)
- Blood pressure should be monitored, and MAP maintained above 60 mm Hg and SAP above 90 mm Hg
  - Hypotension = MAP < 60 mm Hg, SAP < 90 mm Hg
    - Treat hypotension
      - Decrease anesthetic depth (by decreasing vaporizer concentration)

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      - Do not administer crystalloid fluids as a bolus
      - Administer IV colloids 10 to 20 ml/kg
      - Hemorrhage resulting in PCV < 20% requires blood transfusion or hemoglobinsubstitute administration
      - Administer inotrope (e.g., dopamine) IV
- Ventilation
  - Manual or mechanical ventilation is necessary in any patient with intracranial mass

- Capnography (measures $EtCO_2$)
  - Normal $EtCO_2$ = 35 to 45 mm Hg
  - Hypoventilation ($EtCO_2$ > 45 mm Hg) requires immediate assisted or mechanical ventilation or adjustments in ventilation
- Arterial blood gas analysis of CO_2
  - More accurate than capnography
  - Normal $Paco_2$ = 35 to 45 mm Hg
  - Hypoventilation ($Paco_2$ > 45 mm Hg) requires immediate assisted or mechanical ventilation or adjustments in ventilation

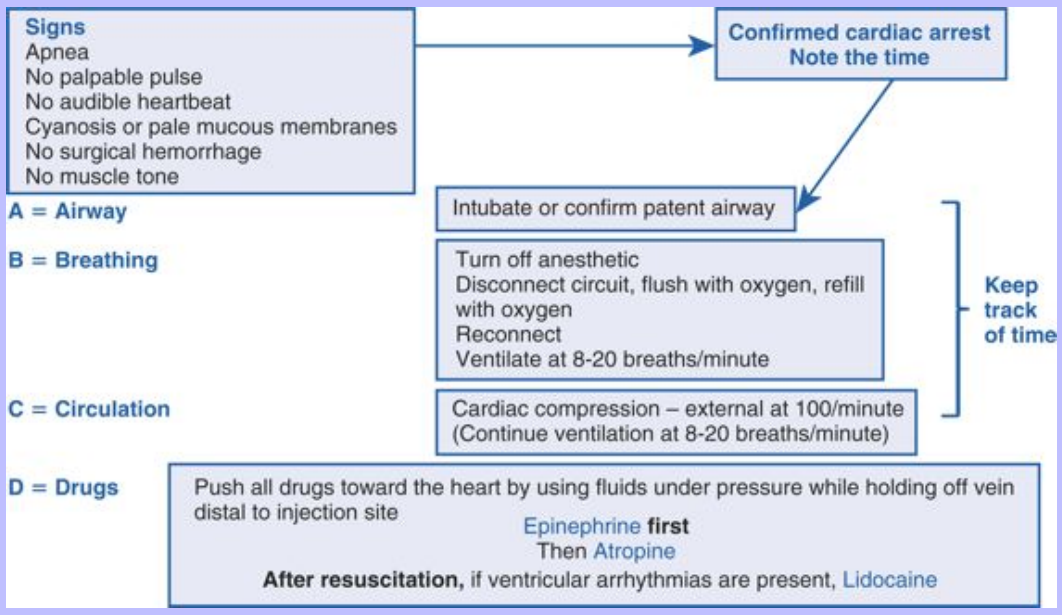
- Temperature
  - Mild hypothermia (core temperature decreases as little as 1.5° to 3°C) confers dramatic cerebral protection against ischemic insult
  - Moderate (3° to 5°C decrease from core temperature) to severe (5° to 7°C decrease from core temperature) hypothermia should be avoided

7.11.8 Recovery

- Goal is quiet, smooth, pain-free recovery from anesthesia
- Provide postoperative analgesia
- Keep patient in stimulus-free environment
- Dry patient if it is wet
- Shivering increases metabolic oxygen consumption by up to 200% and should be avoided; aggressively warm patient with recirculating heating pad, plastic bubble wrap, aluminum body wrap, warmed IV fluids, warm water bottles, forced-air heating units

8 Chapter 8 Cardiopulmonary Resuscitation

Figure 8-1 Cardiopulmonary resuscitation in small animal species.



Volume to use per animal	Epinephrine (1:1000)	Atropine (0.54 mg/ml)	Lidocaine (20 mg/ml)
Newfoundland (65 kg)	0.7 ml	4.8 ml	13 ml
German shepherd (45 kg)	0.45 ml	3.3 ml	9 ml
Springer spaniel (20 kg)	0.2 ml	1.4 ml	4 ml
Cocker spaniel (12 kg)	0.12 ml	0.84 ml	2.4 ml
Cat (5 kg)	0.05 ml	0.4 ml	0.25 ml

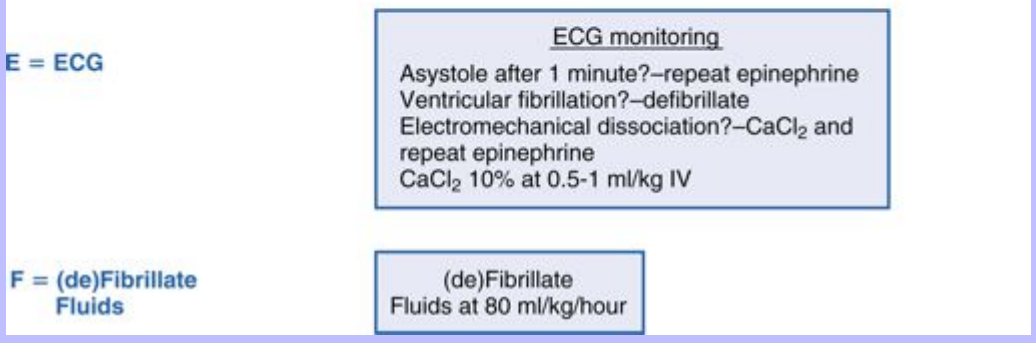
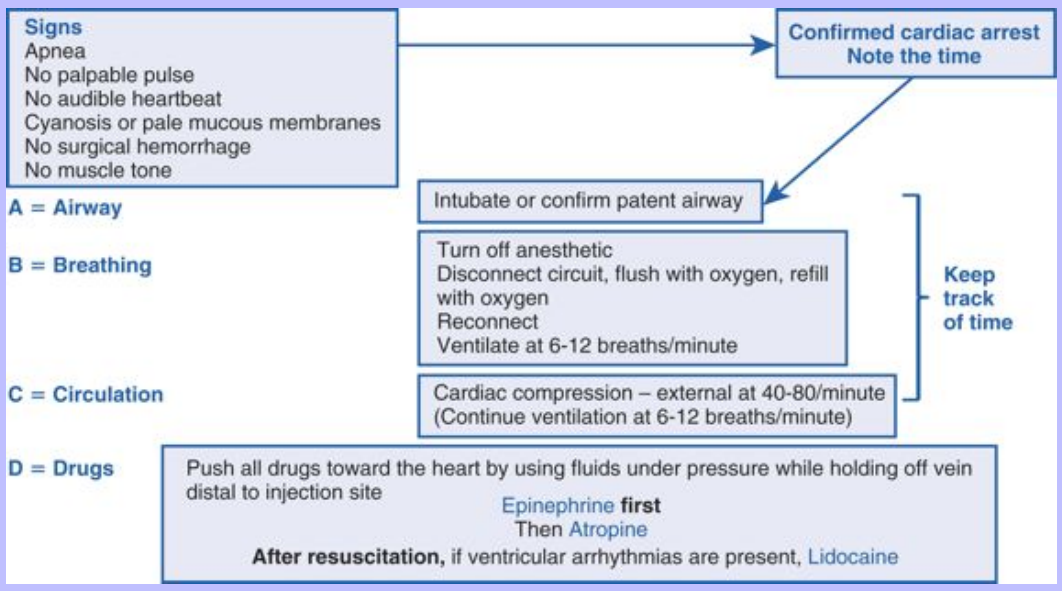


Figure 8-2 Cardiopulmonary resuscitation in large animal species.



Volume to use per animal	Epinephrine (1:1000)	Atropine (0.54 mg/ml)	Lidocaine (20 mg/ml)
Horse, cow (450 kg)	5 ml	8 ml	10-20 ml
Foal, calf, sheep, goat (50 kg)	0.5-1 ml	1-4 ml	5-10 ml
Pig (150 kg)	1-2 ml	5-6 ml	15-30 ml
Piglet (5 kg)	0.05 ml	0.2 ml	0.5-1 ml

E = ECG

ECG monitoring

Asystole after 1 minute?–repeat epinephrine
Ventricular fibrillation?–defibrillate
Electromechanical dissociation?–$CaCl_2$ and repeat epinephrine
$CaCl_2$ 10% at 10 ml/100 kg IV

F = (de)Fibrillate
Fluids

(de)Fibrillate
Fluids at 80 ml/kg/hour

9 Back Matter

9.1 Appendix

9.1.1 APPENDIX A Miscellaneous Information

9.1.1.1 NORMAL RANGES AND CONVERSION TABLES

Table A-1 Normal Temperature Ranges*

Horses	99.5	100	100.5	101	101.5	102	102.5	103	103.5
	37.5	37.8	38.1	38.3	38.7	38.9	39.1	39.4	39.7
Cows	99.5	100	100.5	101	101.5	102	102.5	103	103.5
	37.5	37.8	38.1	38.3	38.7	38.9	39.1	39.4	39.7
Sheep	99.5	100	100.5	101	101.5	102	102.5	103	103.5
	37.5	37.8	38.1	38.3	38.7	38.9	39.1	39.4	39.7
Goats	99.5	100	100.5	101	101.5	102	102.5	103	103.5
	37.5	37.8	38.1	38.3	38.7	38.9	39.1	39.4	39.7
Pigs	99.5	100	100.5	101	101.5	102	102.5	103	103.5
	37.5	37.8	38.1	38.3	38.7	38.9	39.1	39.4	39.7
Dogs	99.5	100	100.5	101	101.5	102	102.5	103	103.5
	37.5	37.8	38.1	38.3	38.7	38.9	39.1	39.4	39.7
Cats	99.5	100	100.5	101	101.5	102	102.5	103	103.5
	37.5	37.8	38.1	38.3	38.7	38.9	39.1	39.4	39.7
Rabbits	99.5	100	100.5	101	101.5	102	102.5	103	103.5
	37.5	37.8	38.1	38.3	38.7	38.9	39.1	39.4	39.7
Ferrets	99.5	100	100.5	101	101.5	102	102.5	103	103.5
	37.5	37.8	38.1	38.3	38.7	38.9	39.1	39.4	39.7

* Shaded areas represent the mean value for that species. These values are for normal resting animals. Temperatures can vary by up to 1° on either side of the mean depending on age, level of activity, and time of day.

Table A-2 Temperature Conversions

Fahrenheit	Celsius
90	32.2
90.2	32.3
90.4	32.4
90.6	32.6
90.8	32.7
91	32.8
91.2	32.9
91.4	33
91.6	33.1
91.8	33.2
92	33.3
92.2	33.4
92.4	33.6
92.6	33.7
92.8	33.8
93	33.9
93.2	34
93.4	34.1
93.6	34.2
93.8	34.3
94	34.4
94.2	34.6
94.4	34.7
94.6	34.8
94.8	34.9
95	35
95.2	35.1
95.4	35.2
95.6	35.3
95.8	35.4
96	35.6
96.2	35.7
96.4	35.8
96.6	35.9
96.8	36
97	36.1
97.2	36.2
97.4	36.3
97.6	36.4
97.8	36.6
98	36.7
98.2	36.8
98.4	36.9
98.6	37
98.8	37.1
99	37.2
99.2	37.3
99.4	37.4
99.6	37.6
99.8	37.7
100	37.8

100.2	37.9
100.4	38
100.6	38.1
100.8	38.2
101	38.3
101.2	38.4
101.4	38.6
101.6	38.7
101.8	38.8
102	38.9
102.2	39
102.4	39.1
102.6	39.2
102.8	39.3
103	39.4
103.2	39.6
103.4	39.7
103.6	39.8
103.8	39.9
104	40
104.2	40.1
104.4	40.2
104.6	40.3
104.8	40.4
105	40.6
105.2	40.7
105.4	40.8
105.6	40.9
105.8	41

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9.1.1.1.0.1

Fahrenheit

Freezing point = 32°F

Boiling point = 212°F

Difference = 180 degrees

9.1.1.1.0.2

Celsius

Freezing point = 0°C

Boiling point = 100°C

Difference = 100 degrees

Each Celsius degree is equivalent to 1.8 Fahrenheit degrees

5 Celsius degrees are equivalent to 9 Fahrenheit degrees

To convert Celsius to Fahrenheit:

$$(°C \times 1.8) + 32 = °F$$
$$\left(°C \times \frac{9}{5}\right) + 32 = °F$$

To convert Fahrenheit to Celsius:

$$(°F - 32) \times 0.555 = °C$$
$$(°F - 32) \times \frac{5}{9} = °C$$

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Table A-3 Body Weight Conversion

Pounds	Kilograms
1	0.5
2	0.9
3	1.4
4	1.8
5	2.3
6	2.7
7	3.2
8	3.6
9	4.1
10	4.5
11	5
12	5.4
13	5.9
14	6.4
15	6.8
16	7.3
17	7.7
18	8.2
19	8.6
20	9.1
25	11.4
30	13.6
35	15.9
40	18.2
45	20.4
50	22.7
55	25
60	27.2
65	29.5
70	31.8
75	34.1
80	36.3
85	38.6
90	40.9
96	43.6
100	45.4
110	49.9
120	54.5
130	59
140	63.6
150	68.1
200	90.8
250	113.5
300	136.2
350	158.9
400	181.6
450	204.3
500	227
550	249.7
600	272.4
650	295.1

700	317.8
750	340.5
800	363.2
850	385.9
900	408.6
950	431.3
1000	454
1100	499.4
1200	544.8

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Table A-4 Normal Heart Rates*

Horses	20	30	40	50	60	70	80	90	100	110	120	140
Cows	20	30	40	50	60	70	80	90	100	110	120	140
Sheep	20	30	40	50	60	70	80	90	100	110	120	140
Goats	20	30	40	50	60	70	80	90	100	110	120	140
Pigs	20	30	40	50	60	70	80	90	100	110	120	140
Dogs	60	80	100	120	140	160	180	200	220	240	250	
Cats	60	80	100	120	140	160	180	200	220	240	250	
Rabbits	60	80	100	120	140	160	180	200	220	240	250	
Ferrets	60	80	100	120	140	160	180	200	220	240	250	

* Shaded areas indicate the normal range for that species. These rates apply to normal resting animals. Rates can vary with age, environmental temperature, the stress of restraint, and other factors.

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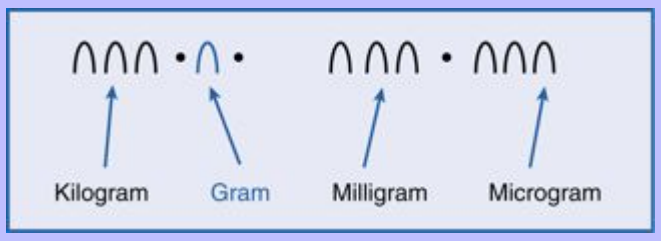
Table A-5 Normal Respiratory Rates*

Horses	8	10	12	16	20	24	30	40	50	60
Cows	8	10	12	16	20	24	30	40	50	60
Sheep	8	10	12	16	20	24	30	40	50	60
Goats	8	10	12	16	20	24	30	40	50	60
Pigs	8	10	12	16	20	24	30	40	50	60
Dogs	8	10	12	16	20	24	30	40	50	60
Cats	8	10	12	16	20	24	30	40	50	60
Rabbits	8	10	12	16	20	24	30	40	50	60
Ferrets	8	10	12	16	20	24	30	40	50	60

* Shaded areas indicate the normal range for that species. These rates apply to normal resting animals. Rates can vary with age, environmental temperature, the stress of restraint, and other factors.

Table A-6 Kilograms, Milligrams, and Micrograms Listed in Descending Order

Kilograms 1000 times 1 × 10^3	Grams 1 unit 1	Milligrams 1000th 1 × 10^{-3}	Micrograms One millionth 1 × 10^{-6}
Kilograms		*1000.000000*	
Hundreds of grams		*100.000000*	
Tens of grams		*10.000000*	
Grams		1.000000	
Hundreds of milligrams		0.100000	
Tens of milligrams		0.010000	
Milligrams		0.001000	
Hundreds of micrograms		*0.000100*	
Tens of micrograms		*0.000010*	
Micrograms		*0.000001*	



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9.1.1.1.1 Converting Percent Solution to Milligrams per Milliliter

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Percent		
Latin: “centum”	=	“one hundred”
“Percent”	=	“per one hundred”
One percent	=	one gram per one hundred milliliters
1%	=	1 g/100 ml
	=	1000 mg/100 ml
	=	10 mg/ml

Therefore A% =(10 × A) mg/ml

Examples		
2%	=	20 mg/ml
2.5%	=	25 mg/ml
5%	=	50 mg/ml

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9.1.1.2 INHALED AGENTS

9.1.1.2.1 Consumption of Halothane

1 mol halothane liquid → 1 mol halothane vapor

Molecular weight of halothane = 197

1 mol = Molecular weight in grams = 197 g liquid

What Volume of Liquid Is This in Milliliters?

Density = Mass/Volume

Therefore, Volume = Mass ÷ Density

That is, mass (g) ÷ density (g/ml) = ml

Specific gravity = 1.86 (very similar to density)

∴ Volume = 197 g ÷ 1.86 g/ml = 105.9 ml

Therefore, 1 mol = 106 ml of liquid halothane

What Volume of Vapor Would This Become?

For all gases, 1 mol = 24L at room temperature (22.4L at 0°C)

106 ml liquid halothane → 24,000 ml halothane vapor

With Gas Flow at 1L/min and 1.5% Halothane

Halothane makes up 1.5% of 1000 ml/min = 15 ml halothane vapor (remainder of gas flow = 985 ml O_2)

In 1 hour, halothane vapor used= 15 ml × 60 min = 900 ml

However, 1 mol = 24,000 ml

In 1 hour, halothane used = 900 ÷ 24,000 = 0.0375 mole

Liquid required for this

= 0.0375 mole

= 0.0375 × 106 ml

= 3.975 ml (approximately 4 ml)

(Remember that some liquid is lost through vaporization each time the vaporizer is refilled.) *275*

9.1.1.2.2 *276*

Consumption of Isoflurane

1 mol isoflurane liquid → 1 mol isoflurane vapor

Molecular weight of isoflurane = 184.5

1 mol = Molecular weight in grams = 184.5 g liquid

What Volume of Liquid Is This in Milliliters?

Density = Mass/Volume

Therefore, Volume = Mass ÷ Density

That is, mass (g) ÷ density (g/ml) = ml

Specific gravity = 1.496 (very similar to density)

∴ Volume = 184.5 g ÷ 1.496 gm/ml = 123.32 ml

Therefore, 1 mole = 123 ml of liquid isoflurane

What Volume of Vapor Would This Become?

For all gases, 1 mol = 24L at room temperature(22.4 L at 0°C)

123 ml liquid isoflurane → 24,000 ml isoflurane vapor

With Gas Flow at 1 L/min and 2% Isoflurane

Isoflurane makes up 2% of 1000 ml/min = 20 ml isoflurane vapor (remainder of gas flow = 980 ml O_2)

In 1 hour, isoflurane vapor used = 20 ml × 60 min = 1200 ml

However, 1 mol = 24,000 ml

In 1 hour, isoflurane used = 1,200 ÷ 24,000 = 0.05 mol

Liquid required for this

= 0.05 mole

= 0.05 × 123 ml

= 6.15 ml

(Remember that some liquid is lost through vaporization each time the vaporizer is refilled.) *276*

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Consumption of Sevoflurane

1 mol sevoflurane liquid → 1 mol sevoflurane vapor

Molecular weight of sevoflurane = 200

1 mol = Molecular weight in grams = 200 g liquid

What Volume of Liquid Is This in Milliliters?

Density = Mass/Volume

Therefore, Volume = Mass ÷ Density

That is, mass (g) ÷ density (g/ml) = ml

Specific gravity = 1.52 (very similar to density)

∴ Volume = 200 g ÷ 1.52 g/ml = 131.58 ml

Therefore, 1 mol = 132 ml of liquid sevoflurane

What Volume of Vapor Would This Become?

For all gases, 1 mol = 24L at room temperature (22.4L at 0°C)

132 ml liquid sevoflurane → 24,000 ml sevoflurane vapor

With Gas Flow at 1 L/min and 3.5% Sevoflurane

Sevoflurane makes up 3.5% of 1,000 ml/min = 35 ml sevoflurane vapor (remainder of gas flow = 965 ml O_2)

In 1 hour, sevoflurane vapor used = 35 ml × 60 min = 2100 ml

However 1 mol = 24,000 ml

In 1 hour, sevoflurane used = 2100 ÷ 24,000 = 0.0875 mol

Liquid required for this

= 0.0875 mol

= 0.0875 × 132 ml

= 11.55 ml

(Remember that some liquid is lost through vaporization each time the vaporizer is refilled.)

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9.1.1.3 MAC

MAC = Minimum alveolar concentration of an anesthetic agent that will prevent response to a noxious stimulus in 50% of patients.

Table A-7 MAC Values for Inhalant Agents by Species

Species	Halothane	Isoflurane	Sevoflurane
Horses	0.88	1.31	2.31
Cattle	0.76*	NR	NR
Sheep	0.97	1.58	NR
Goats	0.96	1.29	2.33
Pigs	0.94	1.75	2.66
Dogs	0.87	1.28	2.36
Cats	1.14	1.63	2.58
Rabbits	1.39	2.05	3.7
Ferrets	1.01	1.52	2.7

NR, Not reported.

* Calves.

- For surgical anesthesia, aim for an end-tidal concentration of 1.5 × MAC
- Patients must always be monitored closely and settings adjusted as required
- Various factors affect MAC and these must be taken into account when determining the optimum setting to use

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9.1.1.3.0.1

Factors that affect MAC

9.1.1.3.0.1.1

Increased

Fever

Hyperthyroidism

CNS stimulants

- Morphine in horse

Hypernatremia

9.1.1.3.0.1.2

Decreased

Hypothermia

Hypotension

Hypothyroidism

Pregnancy

Increasing age

CNS depressants

- Opioids
- Benzodiazepines
- Other sedatives
- Barbiturates

Hyponatremia

9.1.1.3.0.1.3 No change

Gender

Duration of anesthesia

Anticholinergics

K^+ concentration

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9.1.1.4 SUGGESTED READINGS

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9.1.2

APPENDIX B Drugs and Manufacturers

Table B-1 Drugs and Corresponding Trade Names, Controlled Substance Class, Species Approval Status, and Major U.S. Manufacturer or Supplier

Generic Name of Drug	Trade Name	Controlled Substance Class	Species Approval in U.S.	U.S. Manufacturer or Supplier
Acepromazine	PromAce	—	Dogs, cats, horses not intended for food	Fort Dodge Laboratories
	Aceproject			Vetus Animal Health
Atipamezole	Antisedan	—	Dogs	Pfizer, Inc.
Atracurium	Tracrium	—	Not animals	GlaxoSmithKline
Atropine	Atropine	—	Dogs, cats, horses, cattle, sheep, pigs	Butler Company
	Atroject	—		Vetus Animal Health
Bupivacaine	Marcaine	—	Not animals	Abbott Laboratories
Buprenorphine	Buprenorphine	III	Not animals	Abbott Laboratories
Butorphanol	Torbugesic	IV	Dogs, cats, horses not intended for food	Fort Dodge Laboratories
	Torbutrol			Abbott Laboratories
Detomidine	Dormosedan	—	Horses	Pfizer, Inc.
Diazepam	Diazepam	IV	Not animals	Baxter Healthcare Corporation
				Abbott Laboratories
Dobutamine	Dobutamine	—	Not animals	Baxter Healthcare Corporation
				Abbott Laboratories
Dopamine	Dopamine	—	Not animals	Abbott Laboratories
Doxapram	Dopram	—	Dogs, cats, horses	Fort Dodge Laboratories
Duramorph (Morphine)	Duramorph	II	Not animals	Baxter Healthcare Corporation
Edrophonium	Enlon	—	Not animals	Baxter Healthcare Corporation
				Abbott Laboratories
EMLA Cream	EMLA	—	Not animals	Astra Zeneca Pharmaceuticals
Ephedrine	Ephedrine	—	Not animals	Bedford Laboratories
Epinephrine	Epinephrine	—	Horses, cattle, sheep, pigs, dogs, cats	Butler Company
	Epinject			Vetus Animal Health

	Etomidate	Amidate	—	Not animals	Abbott Laboratories	
	Fentanyl	Sublimaze	II	Not animals	Janssen Pharmaceutica	
	Injectable	Fentanyl			Abbott Laboratories	282
	Fentanyl	Duragesic	II	Not animals	Janssen Pharmaceutica	283
	Transdermal Patch	Fentanyl			Abbott Laboratories	
	Flumazenil	Romazicon	—	Not animals	Roche Pharmaceuticals	
	Furosemide	Furosemide	—	Dogs, cats, cattle, horses	Butler Company	
		Equiphar			Vedco, Inc.	
		Furoject			Vetus Animal Health	
					Abbott Laboratories	
	Glycopyrrolate	Robinul	—	Dogs, cats	Fort Dodge Laboratories	
					Baxter Healthcare Corporation	
	Guaifenesin	Guaifenesin	—	Horses not intended for food	Butler Company	
	Halothane	Halothane	—	Dogs, cats, nonfood animals	Abbott Laboratories	
	Hydromorphone	Hydromorphone	II	Not animals	Baxter Healthcare Corporation	
					Abbott Laboratories	
	Isoflurane	Isoflo	—	Dogs, cats, horses not intended for food	Abbott Laboratories	
		Iso-Thesia			Vetus Animal Health	
	Isoproterenol	Isuprel	—	Not animals	Abbott Laboratories	
	Ketamine	Ketaset	III	Cats, subhuman primates	Fort Dodge Laboratories	
		Ketalar			Abbott Laboratories	
		Keta-Thesia			Vetus Animal Health	283
	Lidocaine	Lidocaine	—	Dogs, cats, horses, cattle; approved as an injectable anesthetic; not approved for antiarrhythmic properties	Abbott Laboratories	284
		Lidoject			Vetus Animal Health	
		Xylocaine			Astra Zeneca Pharmaceuticals	
	Medetomidine	Domitor	—	Dogs over 12 weeks of age	Pfizer, Inc.	
	Meperidine	Demerol	II	Not animals	Sanofi-Synthelabo, Inc.	
		Meperidine			Abbott Laboratories	

	Mepivacaine	Carbocaine	—	Horses not intended for food	Pfizer, Inc. Abbott Laboratories	
	Midazolam	Midazolam	IV	Not animals	Baxter Healthcare Corporation Abbott Laboratories	
	Morphine	Morphine	II	Not animals	Baxter Healthcare Corporation Abbott Laboratories	
	Naloxone	Naloxone	—	Not animals	Abbott Laboratories	284
	Neostigmine	Neostigmine	—	Not animals	Baxter Healthcare Corporation Valeant Pharmaceuticals International	285
	Oxymorphone	Numorphan	II	Not animals	Endo Pharmaceuticals, Inc.	
	Phenylephrine	Phenylephrine	—	Not animals	Baxter Healthcare Corporation Butler Company Abbott Laboratories	
	Propofol	PropoFlo	—	Dogs, cats	Abbott Laboratories	
		Propofol			Baxter Healthcare Corporation	
		Rapinovet			Schering-Plough Corporation	
	Sevoflurane	SevoFlo	—	Dogs, horses not intended for food	Abbott Laboratories	
	Telazol	Telazol	III	Cats, dogs	Fort Dodge Laboratories	
	Thiopental	Pentothal	III	Not animals	Abbott Laboratories	
	Xylazine	Sedazine	—	Dogs, cats, horses, deer, elk	Fort Dodge Laboratories	
		Xylazine X-ject E X-ject SA			Butler Company Vetus Animal Health	
	Yohimbine	Yobine	—	Dogs	Lloyd Laboratories	
		Antagonil	—	Deer, elk	Wildlife Pharmaceuticals, Inc.	285

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9.1.2.1 CONTACT INFORMATION FOR DRUG MANUFACTURERS AND SUPPLIERS

9.1.2.1.1 Abbott Laboratories

1401 Sheridan Road

North Chicago, IL 60064

847-937-6100

1-888-299-7416

http://www.abbott.com

9.1.2.1.2 AstraZeneca Pharmaceuticals LP

1800 Concord Pike

Wilmington, DE 19850-5437

302-886-3000

1-800-456-3669

http://www.astrazeneca-us.com

9.1.2.1.3 Baxter Healthcare Corporation

One Baxter Parkway

Deerfield, IL 60015

Main number: 847-948-2000

Products and services: 847-948-4770; 1-800-422-9837

Clinical and technical information:1-800-262-3784

http://www.baxter.com

9.1.2.1.4 Bedford Laboratories

300 Northfield Road

Bedford, OH 44146

440-232-3320

1-800-521-5169

http://www.bedfordlabs.com

9.1.2.1.5 Burns Veterinary Supply, Inc.

1900 Diplomat Drive

Farmers Branch, TX 75234

972-620-9941

1-800-922-8767

http://www.burnsvet.com

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9.1.2.1.6 Butler Company

5600 Blazer Parkway

Dublin, OH 43017-7524

614-761-9095

1-800-551-3861

http://www.wabutler.com

9.1.2.1.7 Endo Pharmaceuticals

100 Painters Drive

Chadds Ford, PA 19317

610-558-9800

1-800-462-3636

http://www.endo.com

9.1.2.1.8 Fort Dodge Laboratories

(Division of Wyeth)

Overland Park, Kansas 66225-5945

913-664-7000

1-800-533-8536

http://www.wyeth.com/divisions/fort_dodge.asp

9.1.2.1.9 GlaxoSmithKline

5 Moore Drive

Research Triangle Park, NC 27709

1-888-825-5249

http://us.gsk.com

9.1.2.1.10 Janssen Pharmaceutica

1125 Trenton-Harbourton Road

Titusville, NJ 08560

609-730-2000

1-800-526-7736

http://us.janssen.com

9.1.2.1.11 Lloyd Laboratories

P.O. Box 130

Shenandoah, IA 51601

712-246-4000

1-800-831-0004

http://www.lloydinc.com

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9.1.2.1.12 Pfizer, Inc.

812 Springdale Drive

Exton, PA 19341

610-363-3100

1-800-366-5288

http://www.pfizer.com

9.1.2.1.13 Roche Pharmaceuticals

340 Kingsland Street

Nutley, NJ 07110

973-235-5000

1-800-452-9332

http://www.rocheusa.com

9.1.2.1.14 Schering-Plough Corporation

2000 Galloping Hill Road

Kenilworth, NJ 07033-0530

908-298-4000

1-800-224-5318 (small animal)

1-800-211-3575 (large animal)

http://www.sch-plough.com

9.1.2.1.15 Sanofi-Synthelabo, Inc.

90 Park Avenue

New York, NY 10016

212-551-4000

1-800-446-6267

http://www.sanofi-synthelabous.com

9.1.2.1.16 Valeant Pharmaceuticals International

3300 Hyland Avenue

Costa Mesa, CA 92626

714-545-0100

1-800-548-5100

http://www.valeant.com

9.1.2.1.17 Vedco, Inc.

5503 Corporate Drive

St. Joseph, MO 64504

816-238-8840

1-888-708-3326

http://www.vedco.com

9.1.2.1.18 Vetus Animal Health

See Burns Veterinary Supply, Inc.

9.1.2.1.19 Wildlife Pharmaceuticals, Inc.

1401 Duff Drive, Suite 600

P.O. Box 2126

Fort Collins, CO 80524

970-484-6267

1-877-883-9283

http://www.wildpharm.com

9.1.3 APPENDIX C Abbreviation List

Abbreviation	Definition
ACh	acetylcholine
ADH	antidiuretic hormone
AV	atrioventricular
Ca	calcium
Cl	chloride
CNS	central nervous system
CSF	cerebrospinal fluid
D5W	5% dextrose in water
DEA	U.S. Drug Enforcement Administration
ECG	electrocardiogram
GABA	gamma-aminobutyric acid
GDV	gastric dilatation and volvulus
IM	intramuscular
IP	intraperitoneal
IV	intravenous
K	potassium
LRS	lactated Ringer's solution
MAC	minimum alveolar concentration
Mg	magnesium
Na	sodium
NaCl	sodium chloride
NSAID	nonsteroidal antiinflammatory drug
PVC	premature ventricular contraction
SA	sinoatrial
SC	subcutaneous